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MORLEY RIVER HYDRO

A Conceptual Engineering Study and Economic Analysis

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A Conceptual engineering study and
economic analysis.

by: Yukon Electric Company Limited
and Acres Consulting Engineers Ltd.

for: Energy, Mines and Resources Canada
Remote Community Demonstration Program

February 1984

RCDP/PDCE-16

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A. SUMMARY

The objective of this study was to investigate the economic feasibility of a 500 kW hydro installation on the Morley River in Yukon. The site is approximately 3 km downstream of the point at which the Alaska Highway crosses the river and 50 km southeast of Teslin. The hydro plant would serve Teslin which is now using diesel generated electricity. A secondary objective of the project would be the displacement of 500 k litres of diesel fuel per annum by hydro power.

Basing the investigation on a 500 kW plant an average of 4.3 GWh of energy would be available per year. However, the demand is only 1.715 GWh/a and the peak power demand is 390 kW. Assuming no load growth and no real diesel price increases a 500 kW project is not economic over the long term (10 years).

If a 2% annual increase in either load growth or diesel price is assumed the economics are marginally favourable over the long term and if both factors increased 2% per annum the long term benefits are significant. For this case; however, the short term economics are still unacceptable by the standards of the Yukon Electrical Company Limited.

Résumé

La présente étude avait pour objectif d'examiner la faisabilité économique d'aménager une installation hydro-électrique de 500 kW sur la riviére Morley au Yukon. Le site envisagé se trouve à environ 3 km au sud-est de Teslin. La centrale hydro-électrique desservirait l'agglomération de Teslin qui produit maintenant son électricité avec un matériel diesel. Le projet remplacerait 500 000 litres de carburant diesel par an.

Dans l'hypothèse d'une centrale de 500 kW, l' aménagement étudié pourrait fournir en moyenne 4.3 GWh d'energie par an. La demande n'est cependant que de 1,715 GWh par an et la puissance de pointe se situe à 390 kW. Dans l'hypothèse d'une croissance nulle de la charge et d'une augmentation nulle du prix réel du carburant diesel, une installation de 500 kW n'est pas rentable à long terme (sur une période supérieure à 10 ans).

En cas d'augmentation annuelle de 2% de la charge ou du prix du carburant diesel, le projet serait légère, et rentable à long terme. Si les deux augmentaient à raison de 2% par an, les avantages à long terme seraient considérables. Dans ce cas, cependant, la rentabilité à court terme ne satistait toujours pas aux normes fixées par la Yukon Electrical Company Limited.

B. INTRODUCTION

On May 6, 1982 Yukon Electrical Company Limited and Energy, Mines and Resources Canada entered into an agreement to conduct a study to establish an order of magnitude cost estimate for a proposed hydroelectric power plant on the Morley River in Yukon. Such study was to include a comparison of the unit energy costs of the potential hydro development with that of the existing diesel generation. The site studied is located approximately 3 km downstream of where the Alaska Highway crosses the river, and 40 km southeast of Teslin. The study investigated the economic feasibility of a 500 kW power project to serve Teslin which is presently supplied by a local diesel plant consisting of three units totalling 1150 kW. It is believed that a significant amount of the diesel fuel could be displaced by hydro power form the Morley River.

Yukon Electrical Company Limited contracted the conceptual engineering task to Acres Consulting Services Limited of Calgary. The results of that part of the study are reported in section "C" which includes the conclusions and recommendations emanating from the hydrological studies and the site reconnaissance on page 19.

The general conclusions of the complete study incorporating the results of an economic evaluation conducted by Yukon Electrical Company Limited are detailed in section "D" on page 26.

C. CONCEPTUAL ENGINEERING STUDY

1. INTRODUCTION

The Yukon Electrical Company Limited (YECL) is investigating alternative sources of energy from the present diesel generation for the community of Teslin. As part of this investigation, a site for potential hydroelectric development has been sought. Of the several river systems in the vicinity of Teslin, Morley River appears to possess the most attractive potential for hydroelectric development.

In July 1982, YECL requested Acres Consulting Services Limited to undertake a preliminary evaluation of Morley River as a potential site for a 500 kW hydroelectric development. The scope of this preliminary engineering study included the following:

- a hydrological evaluation of Morley River
- site topographic mapping
- preparation of conceptual designs and associated cost estimates.
- preparation of a report summarizing the findings of the study for submission to YECL.

An interim report detailing the hydrological evaluation was prepared and submitted to YECL. At that time, it was concluded that river flows did not represent a constraint for a run-of-the-river development of 500 kW. This report is included as Appendix A.

A helicopter reconnaissance was conducted in July 1982. A reach of the Morley River, 3 km downstream of the Alaska Highway crossing, was identified as the most attractive site for a potential hydroelectric development. A subsequent walking reconnaissance of the north bank was conducted in June 1983 by YECL staff and Acres personnel. This reconnaissance is documented in Appendix B. In September 1983, reconnaissance of the south bank was undertaken by YECL staff. Their letter report is included as Appendix C.

Kenting Mapping Limited was retained to produce photogrammetric mapping of the project site. Existing aerial photography was utilized to produce a 1:5,000 scale topographic map at 2 metre contour intervals.

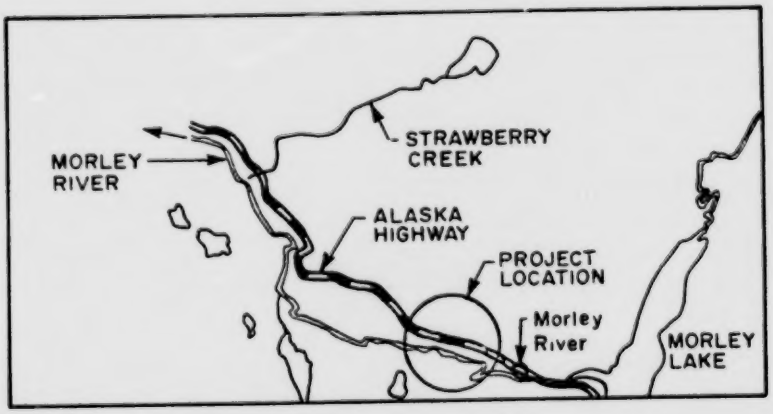
Vertical and horizontal control for photogrammetric mapping was obtained from known points along the Alaska Highway and surrounding area. This was deemed sufficient for preliminary purposes.

2. SITE DESCRIPTION

Morley River is located along the southern boundary of the Yukon Territory. Most of the 1590 km^2 drainage area lies within the Yukon Territory with a small portion in British Columbia. The proposed site is located approximately 230 km west from the town of Watson Lake and 35 km southeast of the community of Teslin, via the Alaska Highway. As illustrated on Figure 1, the proposed site is located on a reach of the river which serves as the outlet channel from Morley Lake to Teslin Lake.

The river falls a total of 110 metres over this reach. Much of the drop is concentrated in the upper part of this reach, immediately downstream from Morley Lake, where numerous waterfalls and rapids are evident. The river has deeply eroded its channel forming a narrow canyon. Twenty to thirty metres of bedrock have been exposed above the waterline at many locations.

The upper part of the banks consist of silty till overlain by organic material. Evidence of instability is obvious at several locations along the banks resulting from the gradual lateral movement of the river undercutting the toe of the banks. The bed of the river consists of a boulder pavement resulting from the erosion of fines with high flow velocities. Bedrock exposures are also evident at several places in the riverbed. The topography is generally rugged and steep over the surrounding area. The only evidence of instability is in the immediate riverbank area. Predominant vegetation consists of heavy growth of coniferous trees and a thick covering of moss.



PROJECT AREA

FIGURE 1

PROJECT LOCATION

ACRES

3. PREVIOUS INVESTIGATIONS

3.1 Hydrology

A hydrological evaluation for the proposed site was undertaken in the initial stages of the conceptual study. During this study, a mean monthly flow duration curve for the proposed Morley River site was assessed and a mean annual flow for the site was established. Regional flood data were analyzed to develop a flood frequency curve for the site. An interim report which detailed the hydrological components of the conceptual engineering study was prepared and submitted to YECL. This report is included as Appendix A.

The mean annual discharge for the site was determined to be 27.1 m^3/s, corresponding to a mean annual runoff volume in the order of 855 million m^3. The flow duration curve for the potential development site was constructed to establish the average potential annual energy output. The results indicated that there is sufficient flow in the Morley River to operate a 500 kW hydro plant at full load for approximately 97 percent of the time. This firm flow is estimated to be 1.6 m^3/s.

The regional flood data were analyzed to determine Morley River flood flows for design purposes. The 1 in 100 year flood was estimated to be 310 m^3/s. This discharge was adopted as the design flood for the project.

4. ALTERNATIVES FOR HYDROELECTRIC DEVELOPMENT

4.1 Potential Site

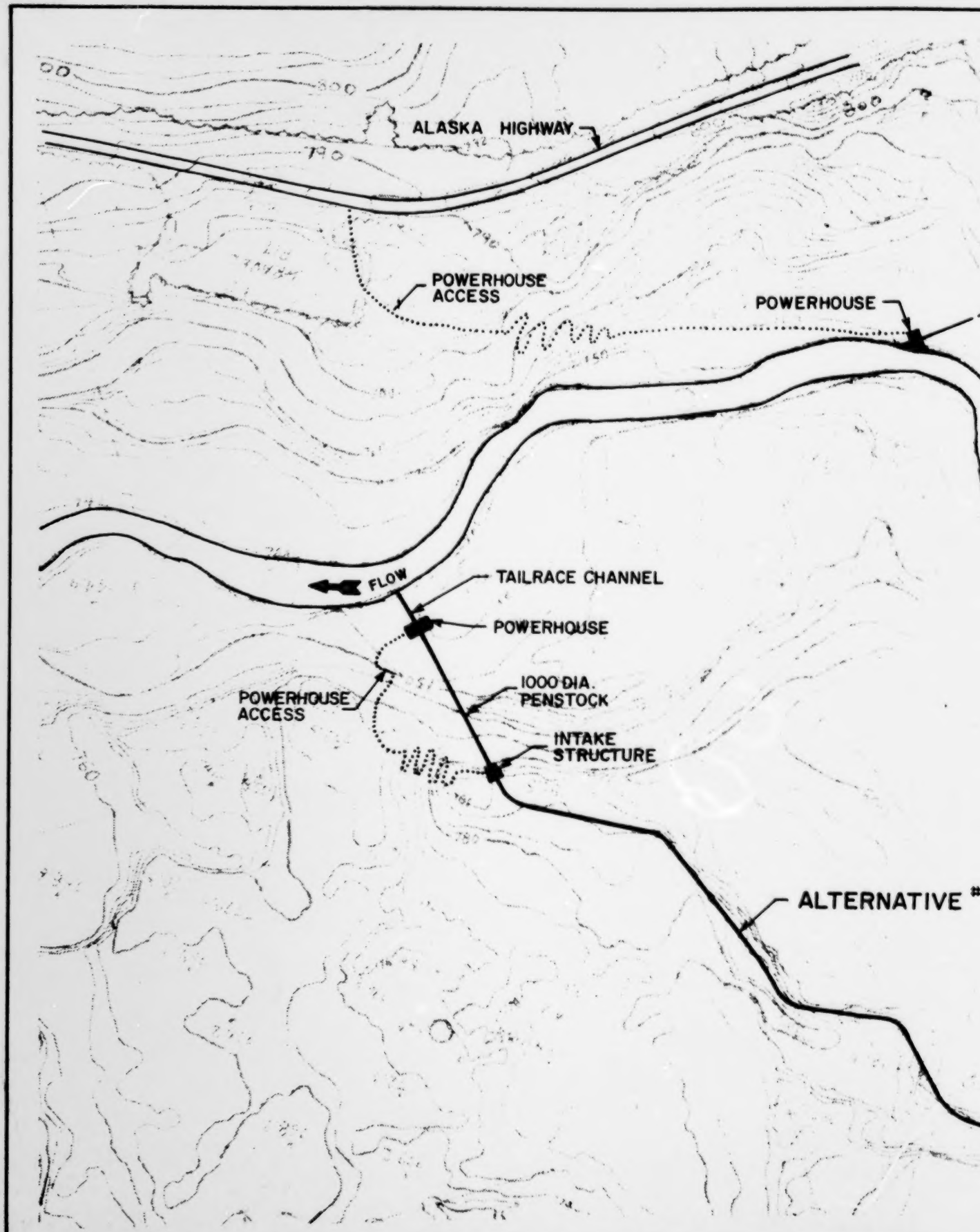
Topographic mapping and field reconnaissances indicated that there is potential for a hydroelectric development on the upper part of the reach of the Morley River between Morley Lake and Teslin Lake. The potential development site is located 3 km downstream of the Alaska Highway crossing. The study area, shown on Plate 1, encompasses the site selected for analysis in this study.

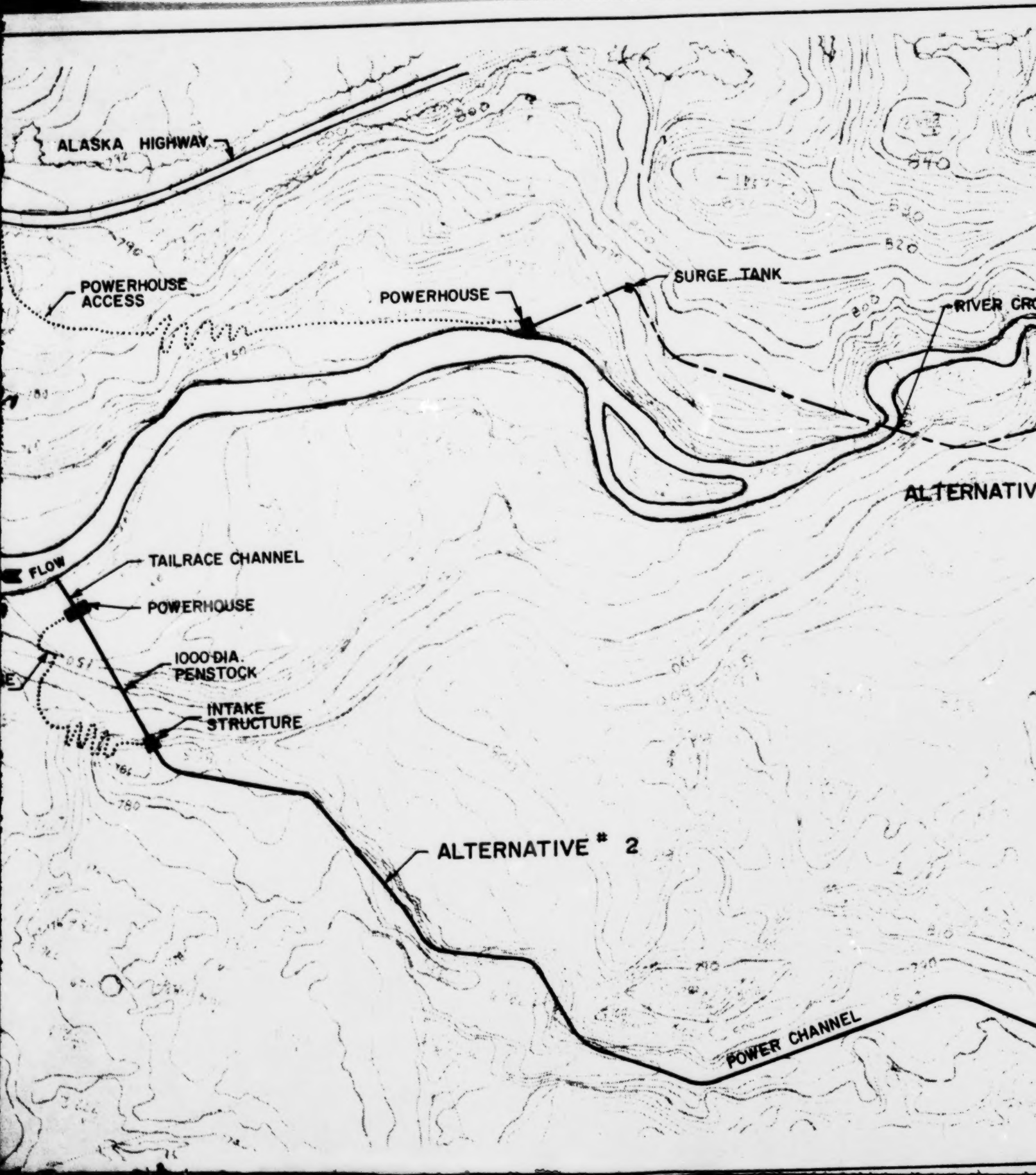
4.2 Alternatives Considered

Two alternative layouts which were initially considered for the proposed development are shown on Plate 1.

The arrangements of the various components for Alternative 1 were devised primarily to simplify access from the Alaska Highway. All major components required for this alternative were located on the north bank of the river to allow access from the Alaska Highway located to the north. A head pond would be formed by a low diversion weir just downstream of the penstock intake structure. Water would pass through a gated intake structure and would then be conveyed to the powerhouse by a 1550 m long, 1200 mm diameter steel penstock which would traverse the walls of the river valley. Two penstock river crossings would be necessary to avoid an unstable area of the north bank. A short tailrace channel would return the water from the powerhouse to the river. The net head available between the intake and powerhouse would be approximately 28 m.

For Alternative 2, a head pond would be formed by a low diversion weir situated across the river. Water would be conveyed by a 1750 m long canal which would be excavated through a natural draw in the topography. The canal would discharge into a 200 m long, 1000 mm diameter, steel penstock which would carry water to the powerhouse


ALASKA HIGHWAY
POWERHOUSE ACCESS
POWERHOUSE
FLOW
TAILRACE CHANNEL
POWERHOUSE
POWERHOUSE ACCESS
1000 DIA. PENSTOCK
INTAKE STRUCTURE
ALTERNATIVE #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RIVER CR
ALTERNATIV
FLOW
TAILRACE CHANNEL
POWERHOUSE
1000 DIA. PENSTOCK
INTAKE STRUCTURE
ALTERNATIVE * 2
POWER CHANNEL

PLATE I

PROPOSED MORLEY RIVER
HYDROELECTRIC DEVELOPMENT
ALTERNATIVE LAYOUTS

located on the south bank. A short tailrace channel would return the water to the river. The net head available is approximately 38 m. Access is anticipated to be from the Alaska Highway river crossing east of the proposed site. A 3.5 km access road would be constructed along the south side of the river from the Alaska Highway to the power channel access.

Table 1 summarizes the heads available for the two alternatives and the lengths of the conveyance systems.

Table 1

COMPARISON OF ALTERNATIVES

Description	ALTERNATIVE 1 (500 kW)	ALTERNATIVE 2 (500 kW)
Gross Head Available	33	40
Net Head	28	38
Length of Canal	--	1750 m
Length of Penstock	1550	200 m
Total Conveyance Length	1550	1950 m

4.3 Selected Alternative

A field reconnaissance of the proposed alignment for Alternative 1, conducted in June of 1983, confirmed that two penstock river crossings would be required to avoid a potentially unstable area on the north bank. It was also observed that the initial 700 m of penstock construction would probably require extensive rock excavation. Since access to the penstock would be difficult over this section of the alignment, high construction costs would be anticipated.

After conducting the field reconnaissance in June 1983, followed by a detailed study of the topographic mapping, the alignment for Alternative 2 was established. It was anticipated that this proposed

route would involve less rock excavation than Alternative 1. A subsequent reconnaissance in September 1983 carried out by YECL staff confirmed the feasibility of Alternative 2.

Alternative 2 was selected for more detailed consideration following an order of magnitude cost comparison of the two schemes. Alternative 2 was estimated to be 70% of the cost of Alternative 1. The components of Alternative 2 are discussed more fully in Section 5.

5. PROJECT COMPONENTS

The following sections describe the various components of Alternative 2. The location and arrangement of the components are illustrated on Plate 1. The conceptual design of the various components has been based on existing precedents for small hydro installations of a similar nature.

5.1 Diversion Weir

A diversion weir, constructed of rockfilled gabions, is proposed to be located across the river downstream of the power channel inlet. It would regulate the level of the forebay to ensure adequate submergence of the penstock intake. To minimize the excavation required for the power channel, the weir would be constructed to an elevation of 786.0. The diversion weir is designed to pass the 1 in 100 year flood flow of 310 m^3/s with an allowable surcharge of 2.0 m. The weir would be approximately 65 m wide and would have a height of about 2.0 m above the river bed. Facilities for upstream fish passage were not provided in the initial design of the diversion weir.

5.2 Power Channel

A 1750 m long power channel is proposed to convey water from Morley River to the penstock intake structure. The channel would be excavated through a natural draw in the topography and would extend to the west from the river. Over the final 850 m of its length the canal would traverse the 784.0 m contour before discharging into the penstock intake.

The channel cross section was based on the assumption that a one metre thick ice cover would be in place. Flow velocities were restricted to permissible levels to ensure formation of the ice cover. The invert of the canal was established to elevation 784.0, yielding a 2.0 metre

depth of flow at full supply level. A freeboard of 2.5 m has been assumed to accommodate the surcharge created during high flows of the river. It is anticipated that the local material from which the channel would be constructed would be sufficiently impermeable to reduce seepage to low levels and would negate the use of a impermeable membrane liner.

5.3 Intake Structure

The penstock intake structure would be located at the terminal of the power channel. The structure would be conventional reinforced concrete and contain a fixed trashrack. A vertical sliding gate would allow dewatering of the penstock.

5.4 Penstock

The penstock would descend a steep hillside conveying water from the power channel to the powerhouse, a distance of approximately 200 m. It is proposed that a steel penstock, having a nominal diameter of 1000 mm, be utilized. The penstock diameter was established from in-house optimization curves for small hydro installations. The short length of the required penstock negates the use of a surge tank or other pressure relief devices normally required for control of water hammer effects.

5.5 Powerhouse

The powerhouse would be located on a natural bench situated above the Morley River. The powerhouse proposed for the development would comprise a reinforced concrete raft substructure accommodating the draft tube and tailrace outlet for the turbine and forming a platform for the support of the turbine and generator equipment. A steel frame building has been assumed for the superstructure. It has also been assumed that a single Osberger turbine unit will be utilized.

Access to the powerhouse would necessitate the construction of a switchback road descending the hillside from the power channel access.

A short tailrace channel approximately 50 m in length would be required to return the water from the powerhouse to the Morley River.

6. POTENTIAL ENERGY

The load factor for the existing diesel generator utilized by the community of Teslin for 1982 was reported by YECL to be 0.50. The peak demand was 410 kW with a total energy of 1.78 GW.h.

The mean annual energy output for the proposed development was computed using the flow duration curve in Appendix A. All inflows in excess of the rated discharge were considered as spillage into Morley River. This spillage would amount to about 94% of the mean annual runoff volume.

The available energy was determined using head versus efficiency curves over the operating range for the proposed unit. From the flow duration curve the weighted average annual potential energy available was calculated to be 4.00 GW.h. Based on the existing demand, approximately 44% of the average potential annual energy would be consumed each year.

A comparison of average available energy, firm energy and existing demand are shown on Table 2.

Table 2

ENERGY ESTIMATES

Average Annual Potential Energy	Average Annual Firm Energy	Existing Annual Energy Demand
4.00 GW.h	3.76 GW.h	1.78 GW.h

7. CAPITAL COST ESTIMATES

An order of magnitude cost estimate for the selected alternative is summarized in Table 3. Material supply costs for the steel penstock were obtained from manufacturers, while installation costs were estimated from in-house data from similar installations in northern Canada. Powerhouse mechanical and electrical costs were estimated from in-house data for turbines, generators and auxiliary electrical equipment. Powerhouse civil costs and the costs shown for the penstock, intake structure, rock gabion weir and power channel were based on material quantities obtained from layout drawings. Appropriate unit prices were obtained from in-house data. Material estimates were based on the 1:5000 scale topographic mapping for the project site. Transmission costs were obtained from YECL. Cost estimates, have been calculated using a 50 percent contingency for civil works and a 20 percent contingency for mechanical/electrical, penstock and transmission facilities.

Table 3

ALTERNATIVE 2
CAPITAL COST ESTIMATE 500 kW

Description	Capital Cost
Care of water	$25,000
Diversion weir	$103,000
Power channel	$217,000
Penstock	$100,000
Intake structure	$77,000
Powerhouse (incl. equipment)	$645,000
Tailrace	$23,000
Access roads	$200,000
Transmission line	$700,000
Subtotal	$2,090,000
Contingencies	$655,000
Capital Cost	$2,745,000
Engineering @ 15%	$410,000
TOTAL CAPITAL COST	$3,155,000

8. CONCLUSIONS AND RECOMMENDATIONS

A hydroelectric development on the Morley River appears to be technically feasible based on hydrological studies and site reconnaissance evaluations.

Morley River would have sufficient flow to operate a 500 kW run-of-the-river plant at full load 97 percent of the time.

Alternative 2, a development situated along the south bank of the river at the proposed site, was selected for further study. This choice was based on an order of magnitude cost comparison which indicated Alternative 2 would be approximately 70% of the cost for Alternative 1. Alternative 1 would also possess a higher risk for construction due to the penstock river crossings and rock excavation along the penstock route.

A 2.0 metre high rockfill diversion weir would form a head pond extending 650 metres upstream to the power channel intake. The diversion weir was designed for the 100 year flood of 310 m^3/s.

The cost estimate for Alternative 2 is $3,155,000 which includes capital costs, contingencies and engineering. It does not include land acquisition or any costs associated with facilities required by the Department of Fisheries and Wildlife.

Based on current estimates of power consumption for the community of Teslin, about 44% of the average potential energy would be utilized in an average year.

It is recommended that the Yukon Electrical Company Limited carry out a financial analysis based on the data contained in this report to confirm the economic feasibility of this development. If the analysis indicates that the proposed development is financially attractive, further feasibility investigations would be required to more accurately define the project layout and cost estimate.

For the Phase II Feasibility Engineering Study, it is recommended that the hydrologic evaluation be reassessed to incorporate new data. This would include flow data from a gauge which has been installed by YECL/Water Survey of Canada at the Alaska Highway bridge crossing of Morley River. The flow-duration analysis should be reassessed to produce a daily flow duration curve. It is also recommended that the regression analyses be extended to include consideration of basin topography and geography. A detailed scope of work for the Phase II Feasibility Engineering Study is contained in Appendix D.

D. ECONOMIC EVALUATION

1. Introduction

Average annual energy available is estimated to be 4.3 GWh. It is estimated that sufficient river flows would be available to operate a 500 kW plant at full load 97% of the time in an average year. The actual energy generation in Teslin was 1.715 GWh in 1983, with a peak demand of 390 kW. Because of this difference between potential hydro energy supply and demand at Teslin, there is excess energy available for potential scale elsewhere and for load growth at Teslin.

The capital cost estimate for a 500 kW installation is 3.155 million $ as reported by Acres in their Conceptual Engineering Study including .7 million $ for transmission, with a 1984 installed cost of 3.35 million $.

The energy calculation is sensitive to the type of turbine used in the installation. The 4.3 GWh relates to the use of an Ossberger turbine. The Acres report indicates 4.0 GWh available using a Francis turbine. Acres made Yukon Electrical Company Limited aware of this increased energy after the reports were released. Yukon Electrical chose to use the more optimistic value in this economic evaluation.

In this study, two load growth assumptions are used. The base assumption is 2% per year, the other is zero growth. Under the zero growth assumption, essentially all of the load is supplied by hydro. A small amount of diesel is assumed for hydro maintenance and to account for the times when the hydro capacity may not be able to meet the peak load. For the 2% growth assumption, an increasing amount of supplementary diesel energy is required each year.

2. Annual Revenue Requirements Comparison - Hydro vs Diesel

The annual revenue requirements for the hydro generated energy are compared to the status quo (with the necessary unit replacements and additions). Specifically, the carrying costs of hydro (return and depreciation) plus a cost for diesel backup energy are compared to the fuel cost of diesel generation plus carrying costs of new diesel units. Operating and maintenance costs are not included as they are assumed to be the same for both diesel and hydro cases. The resulting annual revenue requirements for a 50 year period are present worthed to 1984. Sensitivity tests are done for load growth and the real price increase of diesel fuel.

The cost and economic assumptions used can be found in Appendix E. Summarized results are presented in Table 4 on page 23, the details of which are in Appendix F (Exhibits 1-4).

Table 4 - Net Present Worth, Diesel less Hydro

($K)

Load Growth[1]	Real Diesel Price Increase[1] 0%	2%
0%	- 692	55
2%	70	1247

[1] -annual growth rates

This shows that Morley River Hydro is not economic over the long term under the zero load growth and zero real diesel price increase assumption. A 2% annual increase in either one of these factors results in marginally favorable economics, while a 2% annual increase in both of them together provides a significant long term benefit. However, an examination of the annual revenue requirements (refer to Appendix F) shows that under any assumption, it takes in the order of 10 to 15 years before hydro supplies energy at a cost less than the cost of diesel-fired energy.

Figure F1 (Appendix F) shows, for the base case, the crossover point of the annual revenue requirements, between hydro and diesel. The high initial revenue requirement of hydro gradually decreases wheras the low initial revenue requirement of diesel increases rapidly, corssing over at the 11th year.

3. Diesel Fuel Displaced

Although the economics of Morley River are not overwhelmingly favorable, one obvious benefit of this hydroelectric project is that it will displace a non-renewable resource. The following table shows how much diesel fuel may be displaced under each load growth assumption.

Table 5 - Diesel Fuel Savings

Millions of litres

Load Growth	Annual	50 Year Total
0%	.5	25
2%	Greater than .5	40

4. Energy Cost of Morley River Hydro

It is sometimes useful to examine the cost of the hydro energy alone. One way to do this is to calculate the annual levelized cost of the capital investment and divide by the annual energy to yield a levelized cost in cents/kWh. This can be represented in real or nominal terms.

Table 6 - Hydro Energy Costs

Energy Production	Levelized Cents/kWh Real[1]	First Year Cost[2]
Current Load - 1.72 GW.h	13	29
Full Production - 4.3 GW.h	5	12

[1] - levelizing factor 50 years, 6.6% = .0688
- real rate = 100(1.13/1.06 - 1) = 6.6%

[2] - first year (12 months) revenue requirement divided by energy

The "real" levelized cost is a cost which assumes escalation at 6% per year and can thus be compared with other 1984 costs such as diesel fired energy (34.69 cents/litre -- 3.3kWh/litre = 10.5 cents/kWh).

It should also be mentioned here that the site has poteneial for more capacity and energy. A 1 MW project would have an installed cost (1984) of about 4 $ Million.* At its full production of 8.4 GW.h*, a real levelized cost of 3 cents/kWh and a first year cost of 7 cents/kWh would result

* - YECL estimates, Ossberger turbines.

5. Impact of Capital Grants

Two sensitivity tests were done to see the impact of a capital grant on the long term economics and the annual revenue requirements. With 1 $ M and 0.5 $ M reductions from the original capital cost, ie. 2.32 $ M and 2.85 $ M respectively, the long term economics of hydro improved substantially under the base case assumption (2% load growth and zero real diesel price escalation). However, it still takes in the order of ten years before hydro supplies energy at a cost less than diesel (the "Crossover Year").

A summary of the above results is shown in Table 7 and the details of these are in Exhibits 5 and 6 of Appendix F.

Table 7 - Summary, Capital Grant Cases

Capital Grant ($ Thousands)	Crossover Year	Net Present Worth ($ Thousands)
1000	8	1070
500	10	570

6. Conclusions

1. Based on zero load growth and zero real diesel price escalation, the 500 kW project is not economic over the long term (50 years).

2. A 2% annual increase in either load or diesel price results in marginally favourable long term economics.

3. A 2% annual increase in both factors together results in significant long term benefits.

4. The short term economics are unfavourable under all assumptions used. At least ten years is required before hydro energy is less expensive than diesel.

5. A capital grant of $1 000 000 while improving the long term economics, does not significantly improve the short term economics.

6. At least 500 000 litres of diesel fuel can be displaced each year.

APPENDIX A

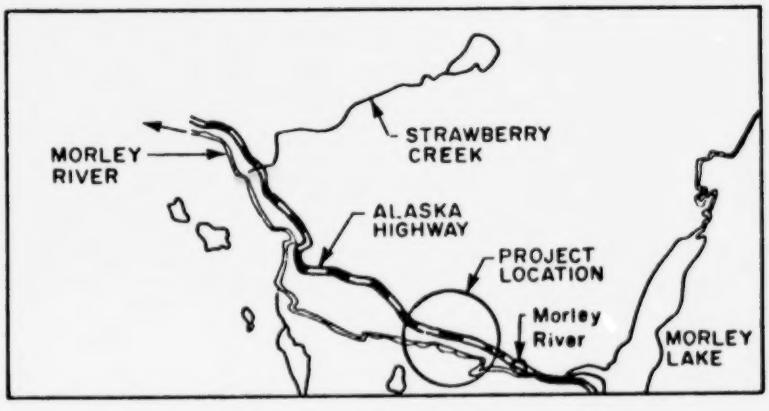
Hydrological Studies

1. INTRODUCTION

The Yukon Electrical Company Limited (YECL) has identified Morley River as a potential site for a 500 kW hydropower development. Morley River is located along the southern boundary of the Yukon Territory (Figure A1). The site under consideration for development is located just downstream from the outlet of Morley Lake. Most of the 1590 km^2 drainage area lies in the Yukon Territory with a small portion in British Columbia. The head available at the site is estimated to be at least 30 m.

In a letter dated July 14, 1982, Acres Consulting Services Limited presented a proposal for Phase I of an evaluation, conceptual design, and cost estimation.

This interim report presents the results of the hydrology study. The remainder of the Phase I study is proposed for early spring 1983 following a field reconnaissance.



PROJECT AREA

FIGURE A1

PROJECT LOCATION

ACRES

2. SCOPE OF WORK

Five tasks were identified for the Phase I hydrology study:

1. Assess the mean monthly flow-duration curve for the proposed Morley River site using regional streamflow and precipitation data.

2. Establish the mean annual flow for the site using regional data.

3. Analyse regional flood frequencies.

4. Establish a procedure to develop flow-duration curves for other basins in the study area.

5. Establish a procedure to determine flood flows for other basins in the study area.

All five tasks have been completed and the results are presented in this interim report.

3. MEAN ANNUAL FLOW

A regional analysis was carried out to determine the mean annual discharge for Morley River. All Water Survey of Canada gauging stations in the vicinity of Morley River having 10 years or more of record were included in the analysis. Twenty-six stations were identified in the southern Yukon Territory and northern British Columbia. These stations are listed in Table A1 and their locations are shown in Figure A2.

A multiple linear regression analysis was performed for the 26 basins with mean annual flow as the dependent variable. The following independent variables were considered:

	Variable	Units
A -	drainage area	km^2
P -	annual precipitation index	mm
A_L -	area of lakes	km^2
A_G -	area of glaciers	km^2
Y_1 -	basin yield = annual runoff/basin area	m
Y_2 -	basin yield = annual runoff/precipitation index	dimensionless

The precipitation index, P, was determined from mean annual precipitation data from the Atmospheric Environment Service. Figure A3 gives contours of this index for the study area. An examination of the values of Y_2, which compares runoff with precipitation, showed that

LEGEND:

X WATER SURVEY OF CANADA STATIONS USED IN HYDROLOGIC ANALYSIS

LIMITS OF HYDROLOGIC ANALYSIS

FIGURE A2

FLOW GAUGE LOCATION PLAN

ACRES

TABLE A1

WATER SURVEY OF CANADA GAUGING STATIONS

STATION NO.	STATION NAME	YEARS OF RECORD: MEAN ANNUAL DISCHARGE (years)	YEARS OF RECORD: PEAK DISCHARGE (years)	DRAINAGE AREA (km^2)	MEAN ANNUAL DISCHARGE (m^3/s)
08AA001	Aishihik River near Whitehorse	29	32	4300	14.2
09AA006	Atlin River near Atlin	31	32	6810	93.0
09AG001	Big Salmon River near Carmacks	18	23	6760	67.1
10AC004	Blue River near the Mouth	17	19	1700	18.2
10AC005	Cottonwood River above Bass Creek	18	18	888	18.8
10AC002	Dease River at McDame	19	23	6940	103.0
10AC003	Dease River at the Outlet of Dease Lake	21	24	1520	15.8
08AA003	Dezadeash River at Haines Junction	28	28	8500	42.2
09AA014	Fantail River at the Outlet of Fantail Lake	18	23	717	21.9
10AB001	Frances River near Watson Lake	16	19	12800	161.0
09AE004	Gladys River at the Outlet of Gladys Lake	20	23	1910	15.1
10AD001	Hyland River near Lower Post	22	30	9450	138.0
10AA001	Liard River at Upper Crossing	21	22	33400	388.0
09AA010	Lindeman Creek near Bennett	24	27	240	9.96

continued...

TABLE A1

WATER SURVEY OF CANADA GAUGING STATIONS (contd)

STATION NO.	STATION NAME	YEARS OF RECORD: MEAN ANNUAL DISCHARGE (years)	YEARS OF RECORD: PEAK DISCHARGE (years)	DRAINAGE AREA (km^2)	MEAN ANNUAL DISCHARGE (m^3/s)
09AA007	Lubbock River near Atlin	14	20	1770	4.54
09AB008	M'Clintock River near Whitehorse	15	25	1700	9.93
09BC001	Pelly River at Pelly Crossing	26	28	49000	384.0
09BC002	Pelly River at Ross River	15	19	18400	187.0
09BA001	Ross River at Ross River	18	19	7250	64.9
09AE003	Swift River at Swift River	21	24	3320	48.4
*09AA011	Tagish Creek near Carcross	5	11	77	0.294
09AC004	Takhini River at the Outlet of Kusawa Lake	20	25	4070	52.0
09AE001	Teslin River near Teslin	30	35	30300	304.0
09AF001	Teslin River near Whitehorse	13	18	36500	331.0
09AA013	Tutshi River at the Outlet of Tutshi Lake	18	23	829	16.3
09AA015	Wann River near Altin	17	23	269	6.96
*09AA009	Watson River near Carcross	9	14	1150	5.10
09AA012	Wheaton River near Carcross	13	22	875	7.87

* Stations used for flood frequency analysis only

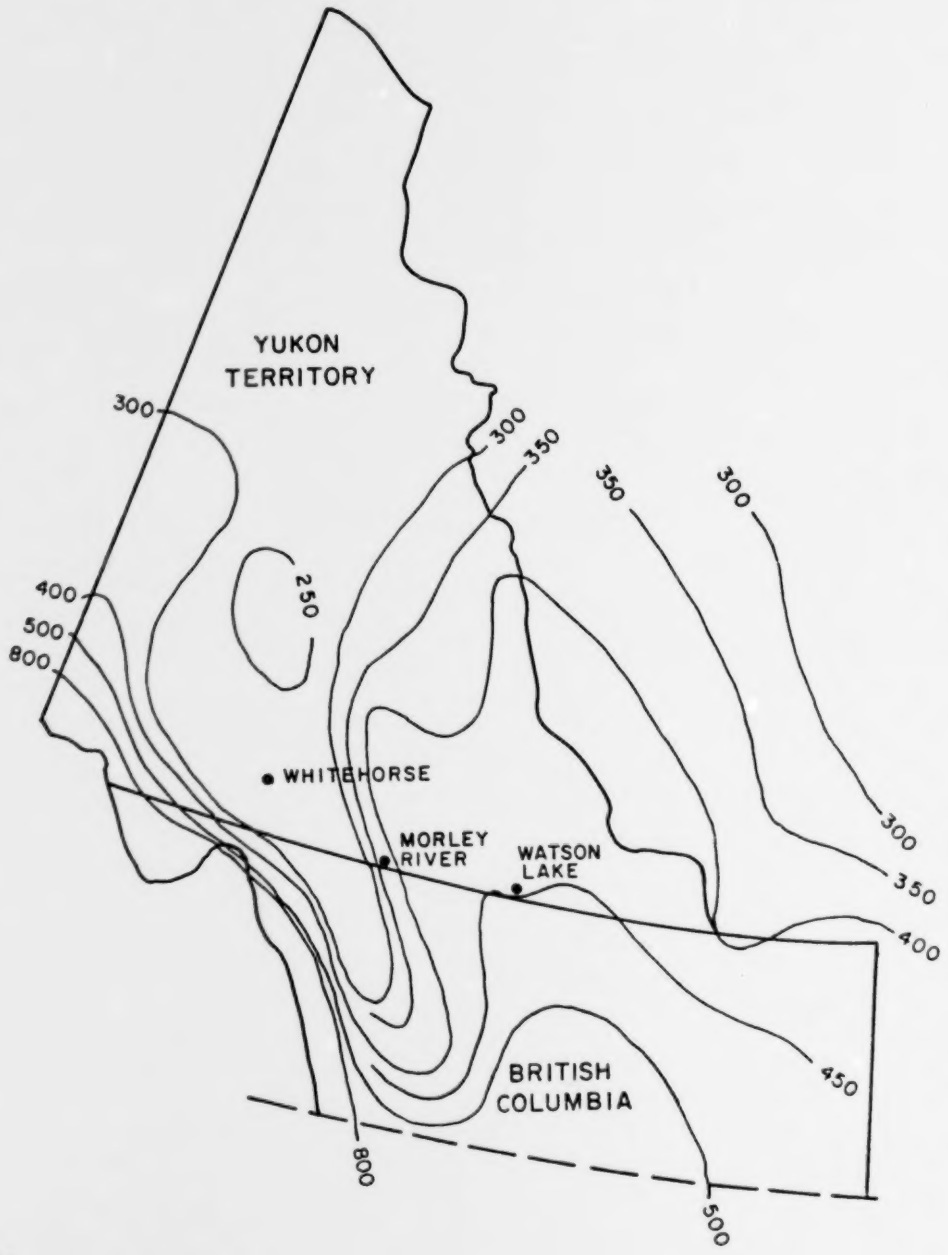


FIGURE A3

PRECIPITATION
INDEX, P

ACRES

for 11 of the 26 basins, Y_2 is greater than one. This is likely the result of the influence of topography on precipitation measurement. Precipitation gauges are often located near population centres which are typcially at lower elevations. However, the total amount of precipitation tends to be greater at higher elevations. As a result, gauge measurements of precipitation may be less than the average precipitation over the area of a drainage basin, particularly in mountainous terrain such as the study area. The precipitation index, P, is likely not equal to the annual precipitation, but it is a relative measure which can be used to compare basins in different areas.

It was found that the variables A_L, A_G, Y_1, and Y_2 were not statistically significant to the regression. Two equations were developed for the mean annual flow, $\overline{Q}$. The first equation uses only the basin area:

$$\overline{Q} = 0.0432\ A^{0.835}$$

For the Morley River drainage area of 1590 km^2, the resulting mean annual flow is 20.4 m^3/s. The correlation coefficient for this equation is 0.908.

The quality of the regression was improved by including the precipitation index. The resulting equation is:

$$\overline{Q} = 2.24 \times 10\text{-}8\ A^{0.87}\ p2.41$$

with a correlation coefficient of 0.963. The estimated precipitation index for the Morley River basin is 410 mm. This gives a mean annual flow estimate of 27.1 m^3/s. Since the correlation coefficient of the second equation is higher, a mean annual flow of 27.1 m^3/s has been adopted for Morley River.

The above equations may be used to determine the mean annual flow for other ungauged basins in the southern Yukon Territory and northern British Columbia. However, their application should be restricted to the area indicated in Figure A2 and they should not be used for basins in the St. Elias Mountains west of the study area.

4. FLOW-DURATION CURVE

The flow-duration curve analysis was adapted from a procedure described by Lane and Lei[1]. A flow duration curve derived from monthly data was determined for each of the 26 basins in the mean annual flow analysis. The variability index I, the slope of the duration curve when plotted on lognormal probability paper, was then determined for each curve (see page A-18 for details).

A multiple linear regression analysis was performed for the 26 stations with I as the dependent variable. The independent variables were the same as those used in the mean annual flow regression. Mean annual flow was also included as an independent variable.

The resulting equation is:

$$I = 1.91 \frac{A_1}{A} - 0.303Y_1 - 0.377$$

where I = variability index
A_L = area of lakes (km^2)
A = basin drainage area (km^2)
Y_1 = basin yeild = annual runoff/basin area (m)

The correlation coefficient is 0.788.

For Morley River, with:

A = 1590 km^2
A_L = 20 km^2
Y_1 = 0.538 m

the value of I is approximately -0.516. The flow-duration curve corresponding to this variability index is illustrated in Figure A4. The procedure for developing this curve is detailed on page A-18.

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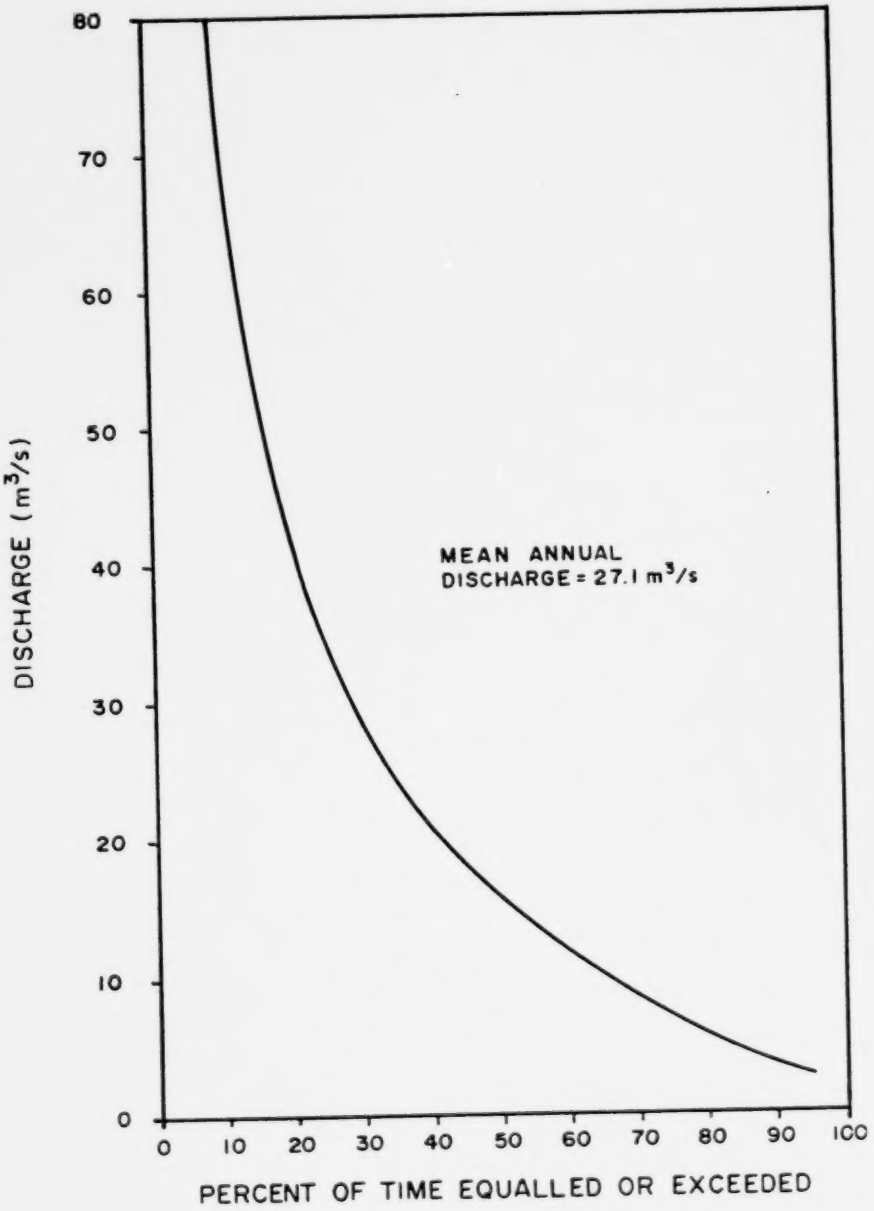
1. Lane, E. W. and Lei, Kai, 1950. Stream Flow Variability. Trans. ASCE, Paper NO. 2418, Vol 115, pp. 1084-1134.



* BASED ON MONTHLY DATA

FIGURE [illegible]

MORLEY RIVER
FLOW DURATION CURVE*

ACRES

The procedure described above and on page A-18 may be used to develop flow-duration curves for other basins in the study area. The geographic limitations are as specified for the mean annual flow equation.

5. FLOOD FREQUENCIES

A regional flood frequency analysis was conducted to determine flood flows for Morley River for spillway design. The data set was expanded from 26 to 28 stations. The two additonal stations have short continuous flow records but more than 10 years of peak flow data.

A frequency analysis of annual peak daily discharges was conducted for each station. It was found that a three-parameter lognormal distribution generally gave the best fit with the data and it was used for all stations. The 10, 20, 50 and 100-year floods and their 95 percent confidence limits were estimated. From the available data, it was estimated that instantaneous flows averaged 13 percent greater than daily discharges.

A multiple linear regression analysis was conducted for each return period with the instantaneous flood flows as the dependent variable and the same independent variable set as used in the flow-duration curve analysis.

For Morely River, the flood flow estimates are:

Return Period (years)	Flood Estimate (m^3/s)	Upper 95% Confidence Limit (m^3/s)
10	210	260
20	240	310
50	280	390
100	310	450

Flood frequency curves are plotted in Figure A5.

The regression equations for flood flows are given below. These equations may be used to estimate flood flows for other ungauged basins in the area, subject to the same geographic restrictions as described in Section 3 of this Appendix.

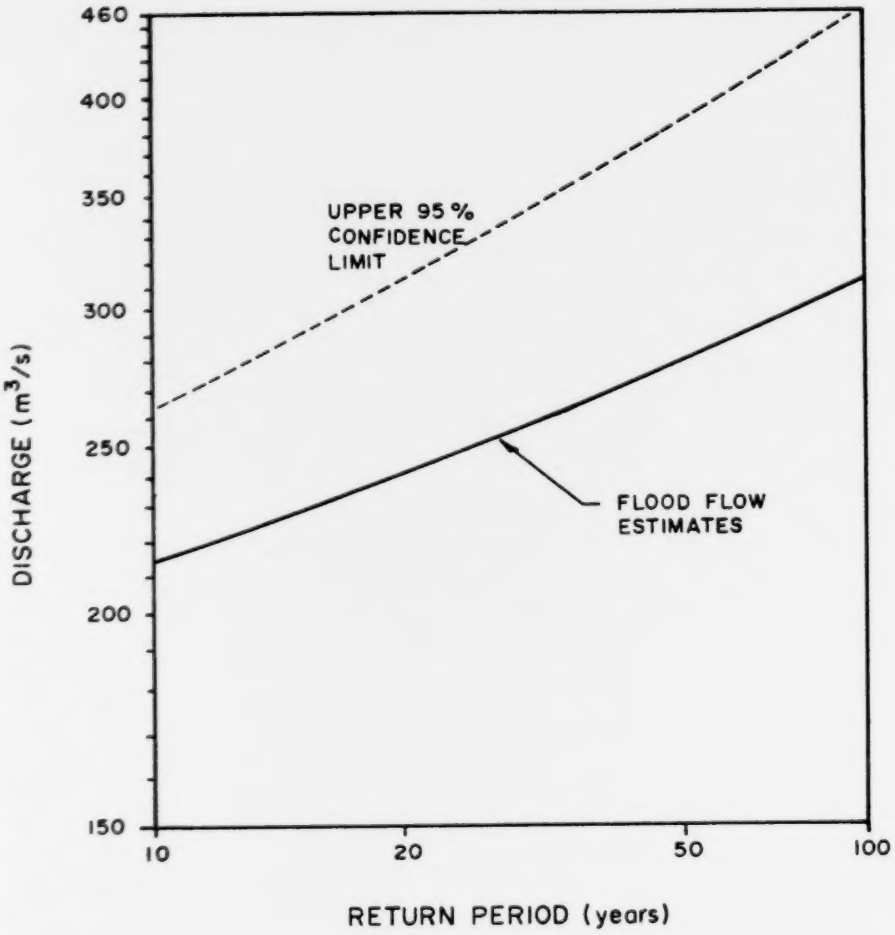


FIGURE A5

MORLEY RIVER
FLOOD FREQUENCIES

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RETURN PERIOD (years)	EQUATION	CORRELATION COEFFICIENT
10	$Q_{10} = 9.15\ \overline{Q}^{0.999}\ A_L^{-0.0470}$	0.987
	$Q_{10,95} = 12.00\ \overline{Q}^{0.980}\ A_L^{-0.0472}$	0.983
20	$Q_{20} = 10.51\ \overline{Q}^{0.992}\ A_L^{-0.0451}$	0.985
	$Q_{20,95} = 14.93\ \overline{Q}^{0.923}$	0.953
50	$Q_{50} = 12.60\ \overline{Q}^{0.940}$	0.979
	$Q_{50,95} = 19.10\ \overline{Q}^{0.912}$	0.970
100	$Q_{100} = 14.10\ \overline{Q}^{0.935}$	0.977
	$Q_{100,95} = 22.70\ \overline{Q}^{0.904}$	0.964

where Q_{10}, Q_{20}...= 10, 20...year flood (m^3/s)

$Q_{10,95}$ = upper 95% confidence limit of 10-year flood (m^3/s)

$\overline{Q}$ = mean annual flow (m^3/s)

A_L = area of lakes (km^2)

6. CONCLUSIONS AND RECOMMENDATIONS

The mean annual flow of the Morley River is estimated to be 27.1 m^3/s. It appears that there would be sufficient flow to operate a 500 kW run-of-the-river plant at full load 97 percent of the time in an average year. Since the plant could be operated at or near capacity most of the time, the Morley River site would maximize energy production for the required capital cost.

It is recommended that the diversion structure for Morley River be designed for the 100-year flood. This is estimated to be 310 m^3/s with an upper 95 percent confidence limit of 450 m^3/s.

It is recommended that the Phase I Conceptual Engineering Study be investigated. The remaining components include ground reconniassance, conceptual layout and cost estimation.

The scope of this hydrology study was sufficient for the purposes of a Conceptual Engineering Study. For the Phase II Feasibility Engineering Study, it is recommended that the hydrologic evaluation be reassessed to incorporate new data. This would include flow data from a gauge which has been installed by YECL/Water Survey of Canada at the Alaska Highway bridge crossing of Morely River. The flow-duration analysis should be reassessed to produce a daily flow duration curve. It is also recommended that the regression analyses be extended to include consideration of basin topography and geography.

Flow-Duration Curves for Ungauged Basins

The flow-duration curve analysis was adapted from a procedure described by Lane and Lei[1]. A flow duration curve derived from monthly data was produced for each of the 26 basins used in the study. Each curve was then plotted on lognormal probability paper and the points were approximated by a straight line. The slope, I, of the line was the variability index for that station.

The axes of lognormal probability paper become linear if the probabilities are converted to the standard normal variate, s, and logarithms are plotted on the y-axis (Figure A6). For a flow-duration curve, the slope of the line, I, as plotted on lognormal paper, is then

$$I = \frac{\log Q}{s}$$

and the line may be represented by the equation

$$\log Q = Is + \log b$$

where I = variability index (slope of the line)
log b = an intercept term

There is an infinite number of lines with any particular value of I. The position of the line with respect to the vertical axis determines the magnitude of the flows. There is only one line with slope I which has a mean annual flow equal to that of the basin under consideration. This line must be found by trial and error. This may be done graphically by plotting lines of equal slope and calculating the mean annual discharge for each until the correct line is found. It may also be done mathematically as described below.

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1. Lane, E.W. and Lei, Kai, 1950. Stream Flow Variability. Trans. ASCE, Paper No. 2418, Vol 115, pp. 1084-1134.

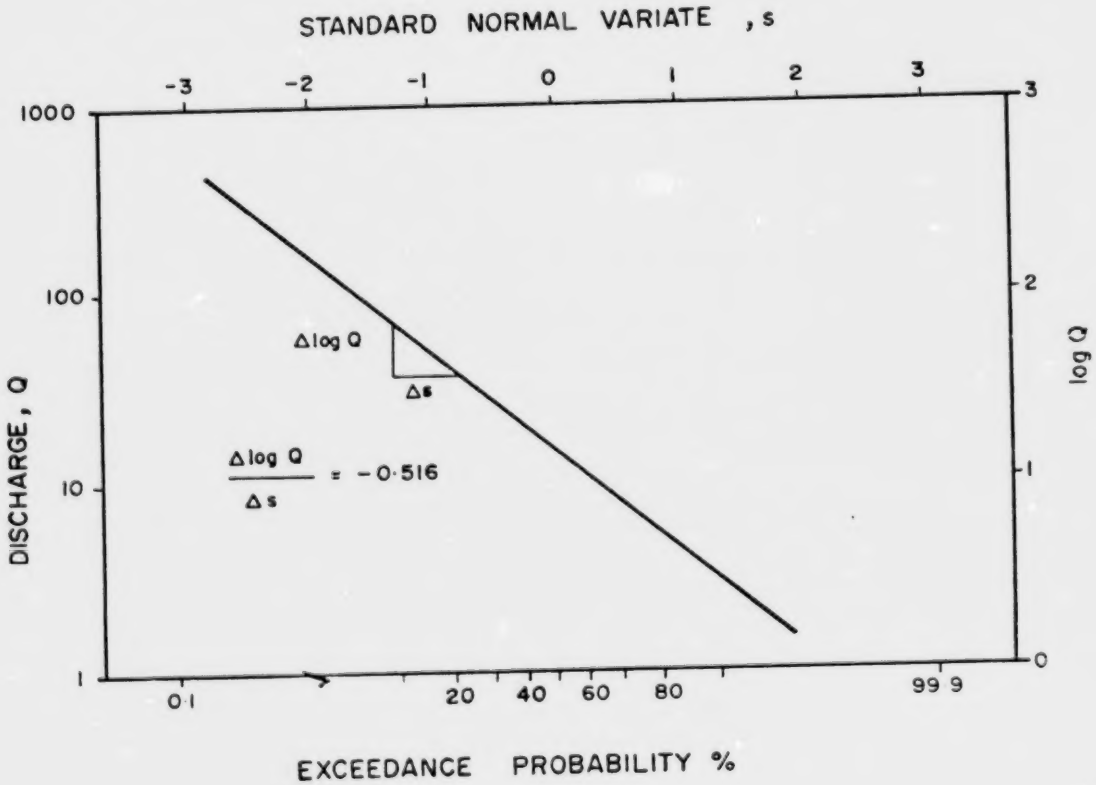

FIGURE A6

FLOW DURATION CURVE FOR MORLEY RIVER ON LOGNORMAL PROBABILITY PAPER

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Example

Morley River Variability Index I = -0.516

Mean Annual Flow $\overline{Q}$ = 27.1 m^3/s

The mean annual flow was calculated from the equation developed in Section A3. The equation of the flow-duration curve is

$$\log Q = Is + \log b$$

A value of b must be determined by trial and error which results in a mean annual flow of 27.1 m^3/s.

The procedure is to assume a value for b and calculate the discharges corresponding to 5, 15, 25, ..., 95 percent probability. To do this, it is necessary to determine the values of s which correspond to these probabilities. These values are found in statistical tables and are given in the table below. The next step is to calculate the mean annual flow. The discharges which have been calculated are the flows at the midpoints of 10 increments of 10 percent probability. The mean annual flow is the sum of the flow times 10 percent for the ten increments.

For our example, assume b = 15.2. The equation for the flows becomes

$$\log Q = -0.516\ s + \log 15.2$$

or

$$Q = 10^{-0.516\ s + \log 15.2}$$

PROBABILITY (%)	s	Q (m^3/S)	0.10 (m^3/s)
5	-1.645	107	10.7
15	-1.0365	52	5.2
25	-0.674	34	3.4
35	-0.385	24	2.4
45	-0.126	18	1.8
55	0.126	13	1.3
65	0.385	10	1.0
75	0.674	7	0.7
85	1.0365	4	0.4
95	1.645	2	0.2
			TOTAL 27.1 m^3/s

The calculated flows Q can now be plotted against probability on linear graph paper to give the flow-duration curve which was presented in Figure A4.

APPENDIX B

Site Reconnaisance

Conducted by Acres/YECL

MEMORANDUM

TO: D.J. Roberts

FILE: P6637.00

FROM: C.P.S. Simonsen/
L.H. Anderson

DATE: July 4, 1983

SUBJECT: Morley River Hydroelecric Project
Site Reconnaissance

Introduction

The following is a report on the reconnaissance to the site of the proposed Morely River Hydroelectric Project of June 15, 1983. The party consisted of:

John Walker - The Yukon Electrical Company Limited.
John W. Murray - Alberta Power Limited
William Peel - Alberta Power Limited
Lloyd H. Anderson - Acres Consulting Services Limited
Carl P.S. Simonsen - Acres Consulting Services Limited.

Messrs. Gary Bauer, General Manager, The Yukon Electrical Company Limited and Mel Orecklin, Department of Energy, Mines and Resources, Canada were present for discussions prior to the reconnaissance but were not able to participate.

Background

This site had been inspected by helicopter in July, 1982. A reach of the river approximately 4 to 6 km downstream from the outlet of Morley Lake had been identified as having hydroelectric potential. This reach was mapped by Kenting Earth Sciences Limited at a scale of 1:5000 showing 2 m contour intervals.

A regional hydrologic study suggests that the discharge of the river is about 1.6 m^3/s or greater, 97 percent of the time.

Using this data a tentative alignment showing diversion weir, intake, penstock, surge tank and powerhouse was developed by Acres. This layout is shown on the attached sketch. One of the criteria of this arrangement was to locate the intake and powerhouse on the right bank to simplify access. This requires two river crossings of the penstock to avoid a landslide area of the right bank. The arrangement was estimated as being capable of developing 28 m of net head thereby meeting the Teslin load of 500 kW, 95 percent of the time.

A water level gauge was installed last year on the Morley River at the highway bridge near the outlet of Morley Lake. This gauge is currently read approximately every two weeks. Water Survey of Canada has metered the section twice.

Reconnaissance

A walkover reconnaissance was made on June 15, 1983 along the right bank from just downstream of the proposed powerhouse site to the intake structure. The approximate route of the walkover is also shown on the attached sketch. The tree cover was very thick and the terrain steep and rugged. Hence, it was difficult at all times to precisely locate oneself. Generally, the upper part of the bank consists of a silty till covered with thick organics. Depth to bedrock is unknown although outcrops were noted in many places. Near the river, bedrock is exposed in most locations to 20 or 30 metres or more above the water level.

Both abutments of the most downstream river crossing of the proposed penstock consist of competent rock.
though some scaling would be required to remove the outside weathered material. It is technically possible to build a penstock crossing at this location though the span would be approximately 60 metres.

Immediately upstream is a slide area along the right bank. Most of the slide is quite old since large diameter trees are growing vertically out of it. The upper end of the slide area appears more active since

the trees are tilting. The reconnaissance confirmed that it would be difficult to construct a penstock across this area; hence, the reason for locating the penstock along the left bank thru this reach.

There were a number of waterfalls and/or very steep rapids in the downstream portion of the canyon.

Near the intake structure the right bank is nearly vertical, hence, it was not possible to get to the water level. Access for construction and operation would be difficult. Construction of a penstock along the side of steep bank would require extensive scaling and rock excavation. Above this very steep part of the bank access to the highway would not be difficult.

Conclusions & Recommendations

The general impression was that it may be costly to construct a penstock along the tentively chosen alignment. Road access to the intake structure would be costly due to large rock cuts over the last 15 to 25 m in elevation. An inclined elevator on the lower slope may be an alternative arrangement. The first 500 m of penstock would be expensive, again due to 15 to 25 m high rock banks. The two river crossings are technically feasible with the pipe supported by a cable or truss system. The remainder of the penstock would be over rugged ground and may require some localized rock excavation but is certainly feasible.

The possibility of locating the works on the left bank was discussed. This alternative is also shown on the attached sketch. In particular a route for either a canal or a penstock thru the saddle around the high ground on the left bank may be less rugged but could involve deep cuts. A higher weir in the river to raise the forebay level moderately and reduce excavation appears feasible, but costs of each would have to estimated and optimized. A permanent single lane bridge would be required to obtain access to the powerhouse and intake structure. Unfortunately, high water prevented crossing of the river to inspect

this route. It is recommended that a reconnaissance of this route be made using YECL personnel as soon as flow conditions allow safe crossing of the river by boat or canoe.

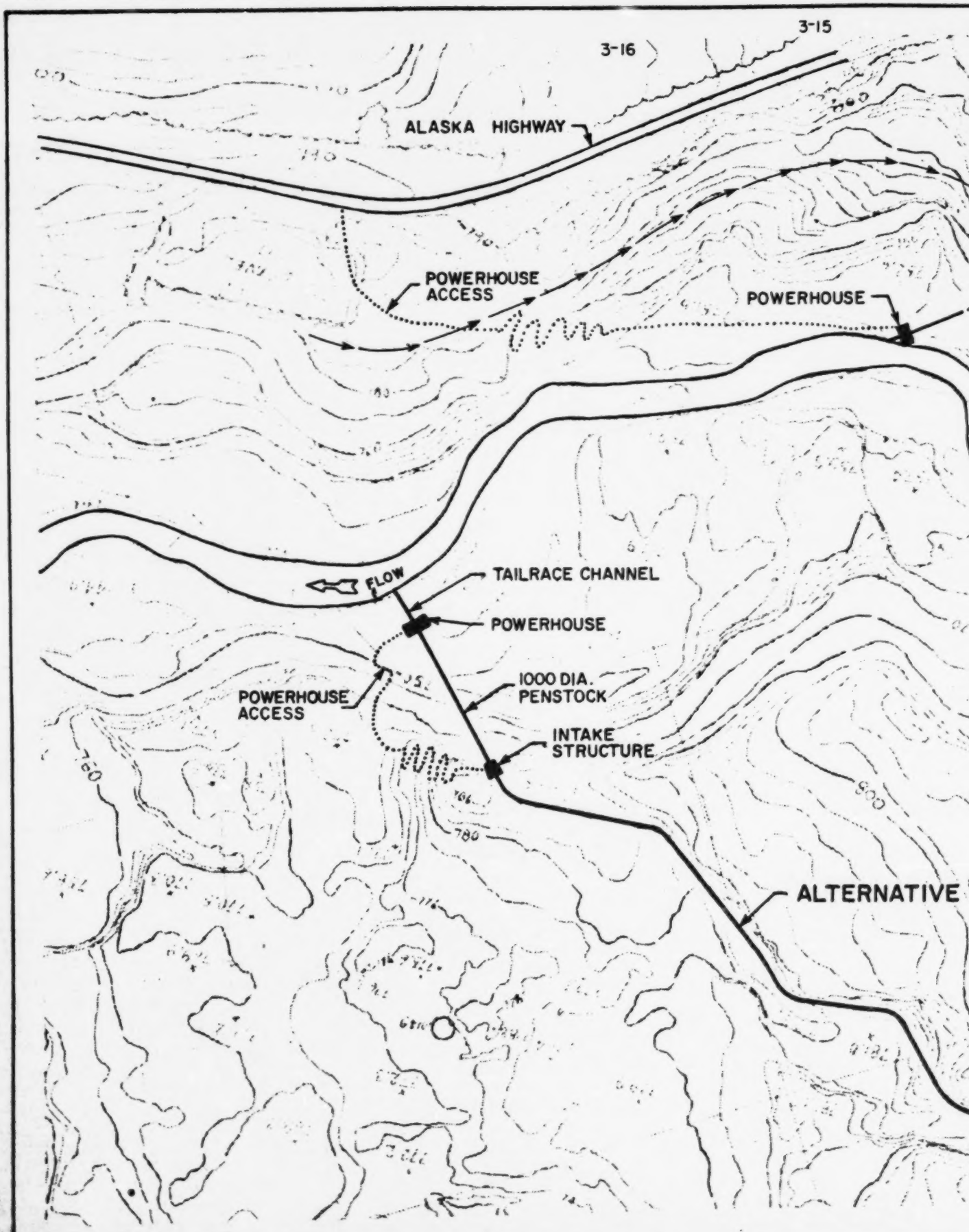
Most of the historical flow data in the Yukon is for larger streams. Runoff characteristics of small watersheds are generally more variable than large watersheds. It is therefore recommended that the water level gauge readings at the Morley River bridge be increased to once a day. If this frequency is too onerous or expensive then the gauge should be read at least two or three times a week plus during and after heavy rainfall. An increase in readings will enhance the confirmation of the hydrology for this small water course. Frequent readings are particularly important during the open water period when river flows are more variable. It may be possible and less expensive to hire someone locally to read the gauge. Efforts should also be considered for additional discharge measurements by Water Survey of Canada in order to establish the stage/discharge curve for the gauge.

Lloyd H. Anderson
L.H. Anderson

C. Simonsen
C. Simonsen

Editor's note:

The numbers 3-1 through 3-18 which appear on Plate 1B refer to colour photographs taken at these locations which have not been reproduced in the printed version of the study report.


3-15
3-16
ALASKA HIGHWAY
POWERHOUSE ACCESS
POWERHOUSE
FLOW
TAILRACE CHANNEL
POWERHOUSE
POWERHOUSE ACCESS
1000 DIA. PENSTOCK
INTAKE STRUCTURE
ALTERNATIVE

RECONNOITRED PATH
SURGE TANK
RIVER CROSSING
1200 DIA PENSTOCK
MORLEY RIVER
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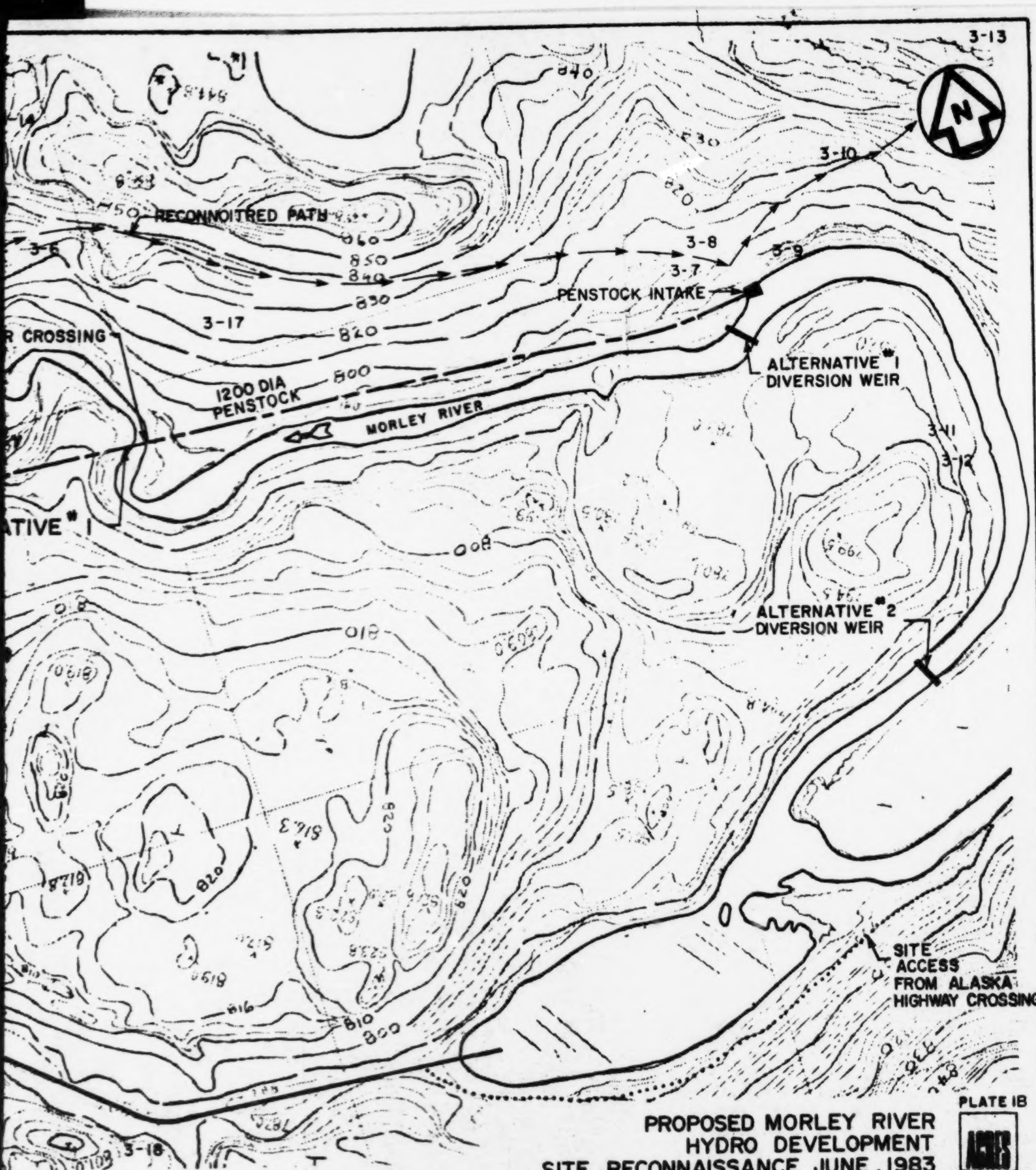
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3-8
3-9
3-7
PENSTOCK INTAKE
3-17
R CROSSING
ALTERNATIVE # 1
DIVERSION WEIR
1200 DIA
PENSTOCK
MORLEY RIVER
3-11
3-12
ATIVE # 1
ALTERNATIVE # 2
DIVERSION WEIR
SITE
ACCESS
FROM ALASKA
HIGHWAY CROSSING
3-18
PROPOSED MORLEY RIVER
HYDRO DEVELOPMENT
SITE RECONNAISSANCE JUNE, 1983
PLATE 18

APPENDIX C

Site Reconnaisance

Conducted by YECL

Editors's note:

The photographs mentioned on the letter of J. Walker as Photo 1 through Photo 9 and whose locations are indicated on Plate 1C as P-1 through P-9 were removed from the study report prior to printing.

THE YUKON ELECTRICAL COMPANY LIMITED

BOX 4190, WHITEHORSE, Y.T. Y1A 3T4 TELEPHONE 668-5211/TELEX 036-8229

September 29, 1983

Mr. Dan Roberts
ACRES
5th Floor
10201 Southport Road S.W.
Calgary, Alberta
T2W 4X9

Re: Morley River

Dear Sir:

On September 22nd, I along with Randy Shippit, made a trip to the Morley River to examine proposed development on the south side of the river. We carried a canoe down to the river from the road and crossed the river a few hundred metres upstream from the head of the canyon.

From there we followed the west bank upstream to the pond. Photos 1 and 2 were taken along this stretch of the river. Photo 3 is of a fallen tree stump on the west bank. It appears from these three pictures that there is more rock on this bank than on the east. As the bank is relatively low for about 30 metres back from the river it appears that this may have been the bottom of the river at one time. In this section the river is eroding the east bank as indicated by the slides in photos 1 and 2.

Photo 4 was taken just downstream of the pond. The material is fine silt which is highly compacted.

Photo 5 is looking east from the end of the pond. The pond appears to be quite deep in spots as we could not see the bottom in most places.

Photos 6 and 7 were taken from the ridge 300 metres west of the pond. From here to the river the ground is stable and we could find no slides where we could get an indication of subsoil composition. From here until we came close to the river we did not come across any surface rock.

At the site of the proposed intake we continued straight west until we intersected the cutline for the gas pipeline. We followed this down to the river and then worked our way upstream to the power house site - photo 8. As can be seen by the boulder in this picture the soil here is quite rocky.

Photo 9 is of the river at this point. The river in this section appears to be quite stable. I do not think the water is travelling fast enough to be transporting rocks in this section.

From the power house site we followed the penstock route up the hill. It appears that it could be possible to develop a scheme at this site with only a 300 metre long penstock. From a point 300 metres up from the plant to your proposed intake the terrain is relatively flat and it may be possible to construct a canal along this section. This could reduce or eliminate the need for a surge tank and/or pressure relief valve.

As per our telephone conversation we would like a report back in six weeks. This report should give some estimate of the capital cost so we can proceed with economic analysis of the development.

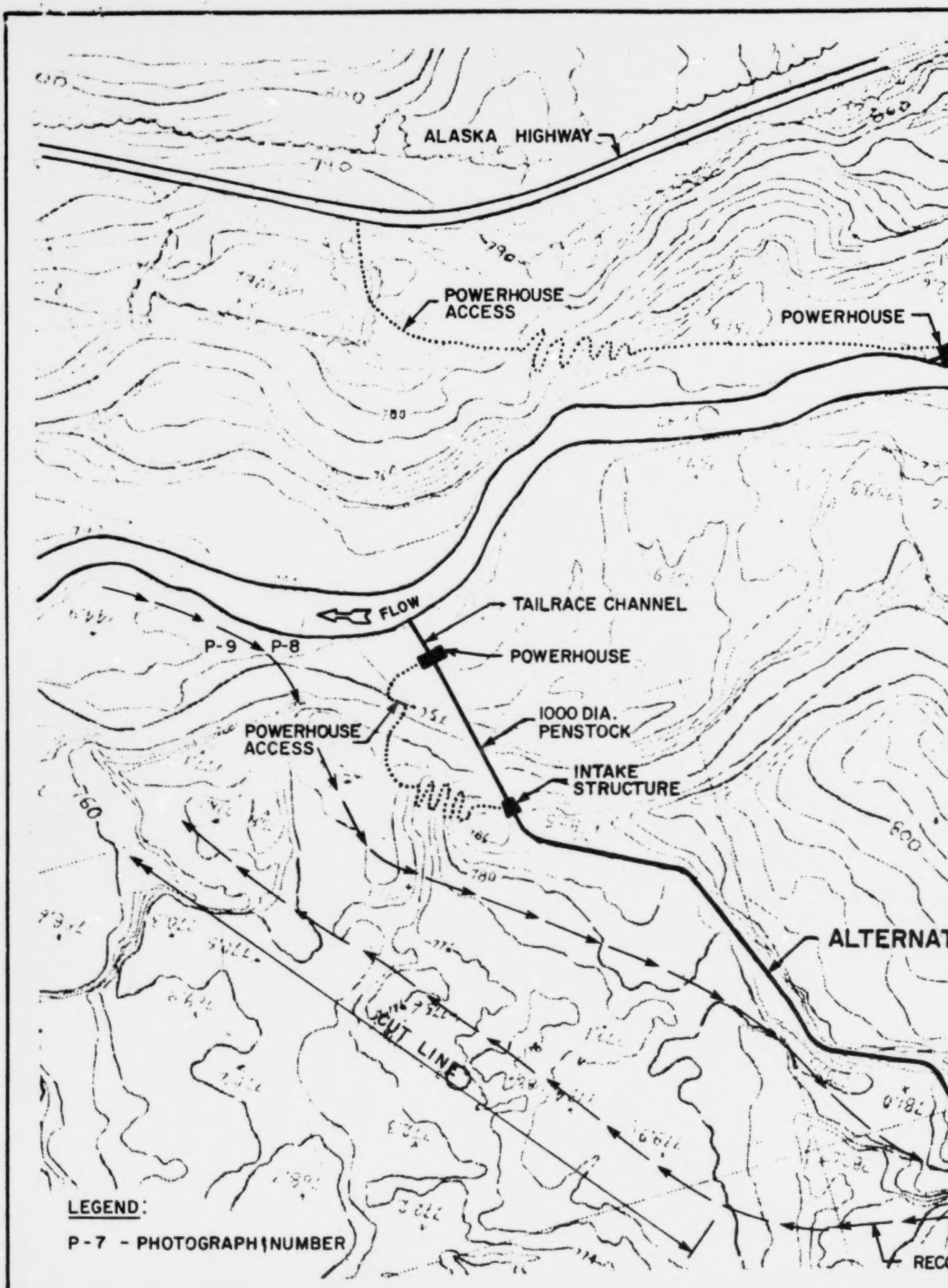
Yours truly,

THE YUKON ELECTRICAL COMPANY LIMITED

John Walker.

J. Walker
Sr. Engineer

JW:ds
Encl.


ALASKA HIGHWAY
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POWERHOUSE
FLOW
TAILRACE CHANNEL
P-9
P-8
POWERHOUSE
POWERHOUSE ACCESS
1000 DIA. PENSTOCK
INTAKE STRUCTURE
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800
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P-7 - PHOTOGRAPH NUMBER
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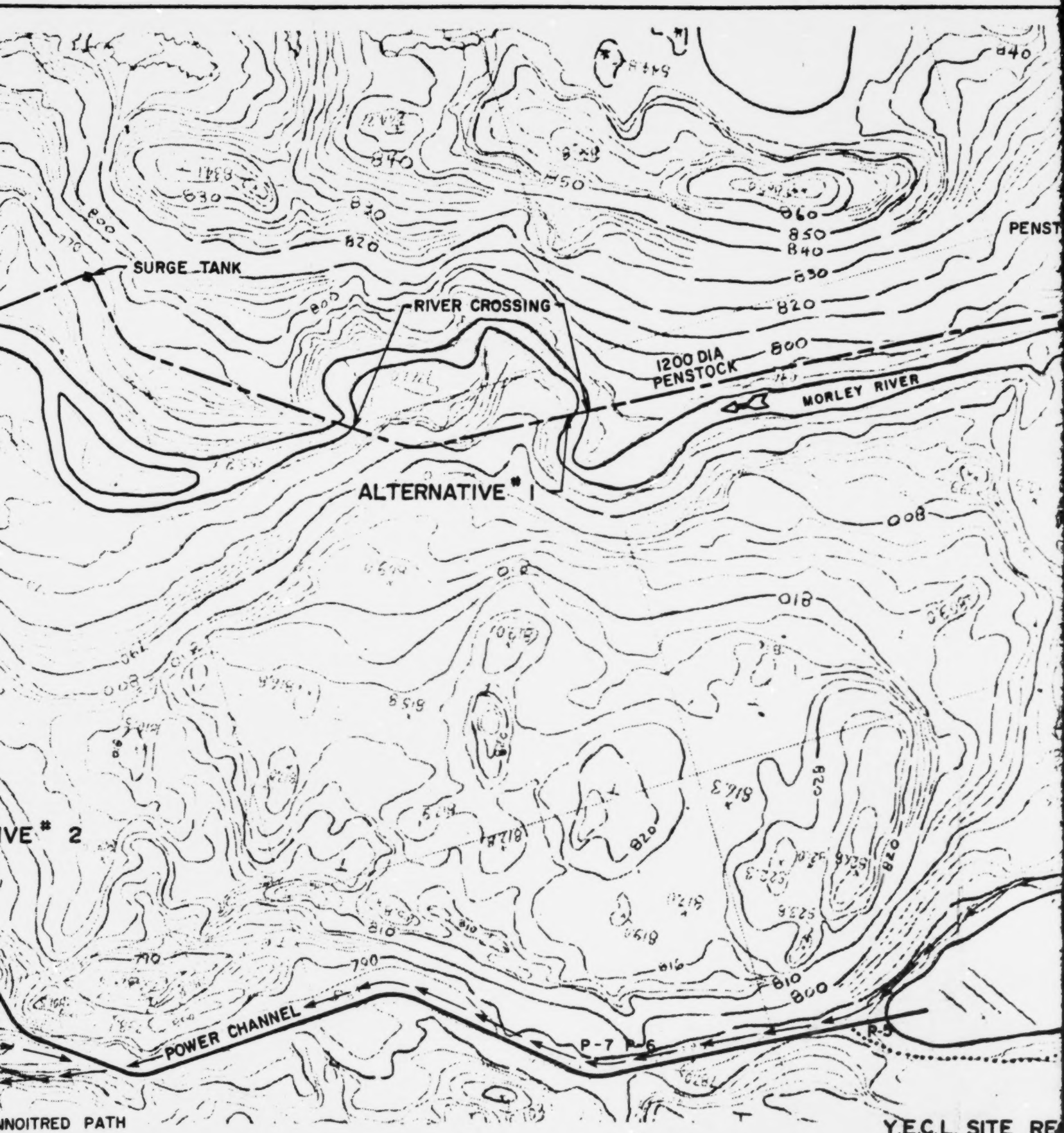
SURGE TANK
RIVER CROSSING
1200 DIA PENSTOCK
MORLEY RIVER
ALTERNATIVE # 1
IVE # 2
POWER CHANNEL
P-7
P-6
P-5
PENST
NNOITRED PATH
Y.E.C.L. SITE RE

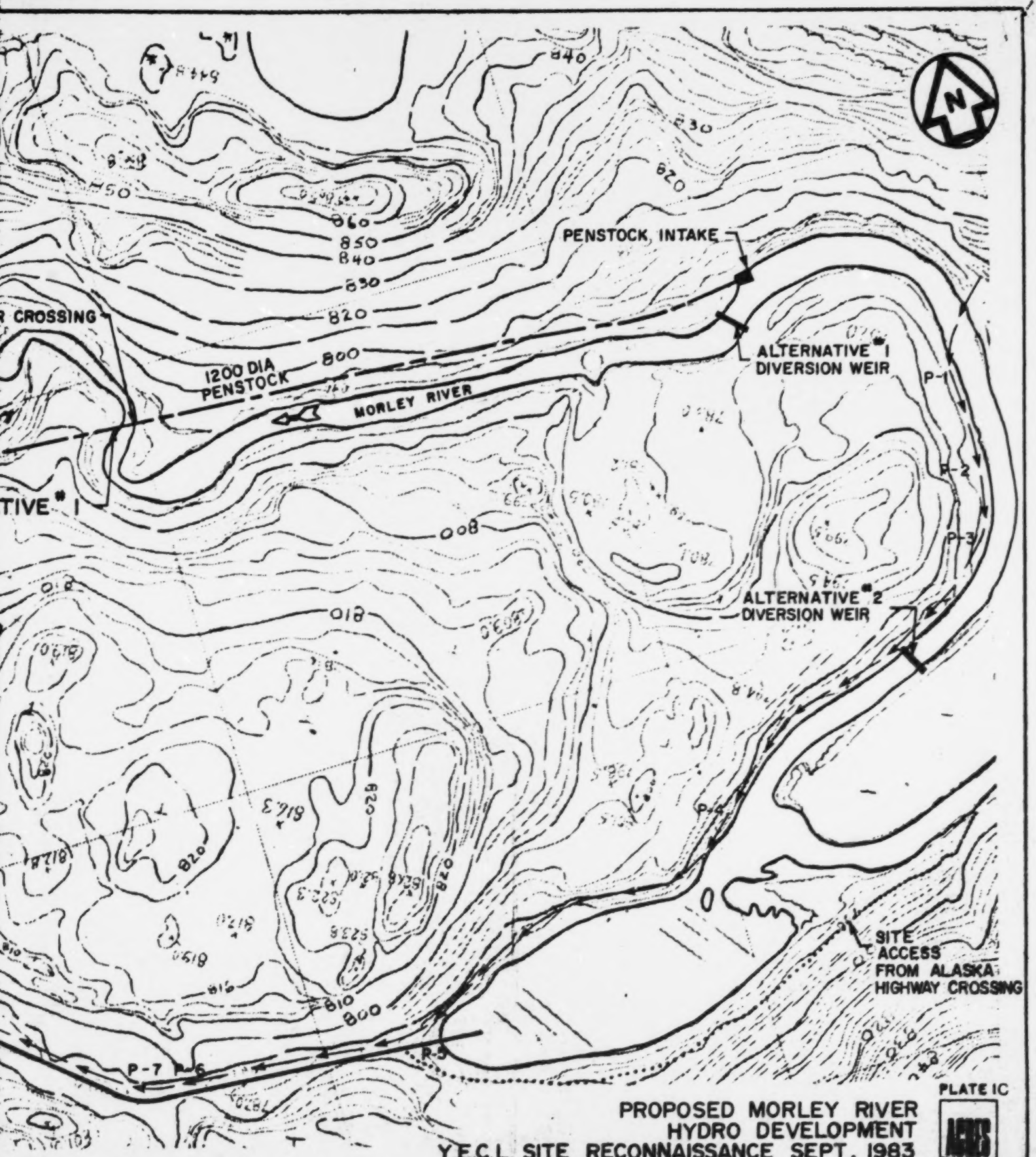

PLATE IC

PROPOSED MORLEY RIVER
HYDRO DEVELOPMENT
Y.E.C.L. SITE RECONNAISSANCE SEPT, 1983

APPENDIX D

Engineering Proposal

by Acres

AGRA

August 16, 1982
W1216.61

The Yukon Electrical Company Limited
P.O. Box 4190
Whitehorse, Y.T.
Y1A 3T4

Attention: Mr. G.K. Bauer, Manager

Dear Sir: Re: Morley River Hydro Potential

Further to our meeting with Mr. John Murray, this letter outlines our letter proposal to undertake engineering studies for the power potential of Morley River at a location downstream of the Alaska Highway crossing. The scope of work has been divided into phases to facilitate control of the study direction and costs by Yukon Hydro Company Limited. This letter proposal defines the scope of work necessary to progress to the application phase and is similiar to the studies recently completed on the proposed McIntyre Creek Plant No. 3.

The following sections outline a proposed scope of work, study schedule and engineering cost estimate for investigations required for licence application to the Yukon Territory Water Board.

1. SCOPE OF WORK

Conceptual Engineering Study - Phase 1

The initial study phase (Phase I) is proposed to establish an order of magnitude cost estimate for a proposed hydroelectric power plant on Morley River. At the completion of this study, unit energy costs of the potential hydro development will be compared with the existing diesel generation. If the potential hydro development is economically attractive, a feasibility study (Phase II) will be proposed.

5th Floor, 10201 Southport Road, S.W., Calgary, Alberta T2W 4X9
Telephone 403-253-9161 Telex 03-825582
Toronto, Burlington, Calgary, Halifax, Niagara Falls, St. John's, Vancouver, Winnipeg

A) Hydrology Work

- assess mean monthly flow-duration curve using regional streamflow and precipitation
- establish the mean annual flow using regional data
- analysis of regional flood frequencies
- undertake a streamflow metering program at Alaska Highway Bridge Crossing (Yukon Hydro Company Limited)

B) Mapping

- confirm the accuracy of the existing form line mapping and establish site mapping with a 2 metre contour interval

C) Conceptual Design/Cost Estimate

- preparation of single line layout based on 500 kw unit
- confirmation of layout by field reconnaissance and preparation of an order of magnitude cost estimate based on "in-house" costs
- determine the mean annual energy based on regional hydrology flow records

D) Report

- prepare a letter-type report outlining the findings of the study together with single line project layout and cost estimate (similar to report - McIntyre Creek Power Potential - Phase 1", October 1980.

2. SCOPE OF WORK

Feasibility Engineering Study - Phase II (Application Phase)

This study phase is proposed to provide sufficient engineering detail to submit an application for a licence to construct a proposed hydroelectric power plant on Morley River.

A) Hydrology Work

- reassess the mean annual flow using streamflow data collected by Yukon Hydro Company personnel
- reassess mean monthly flow duration curve
- prepare an energy simulation

B) Geotechnical Work

- site supervision of drilling of 3 boreholes (if bedrock is located in area of major project components, drilling will not be undertaken)
- site supervision of test pit investigation for borrow material/riprap search
- geotechnical reconnaissance

C) Survey Work

- establish the gross head
- establish the section of intake works and surge tank

D) Feasibility Design

- confirmation of layout
- establish forebay volume
- preliminary optimization of penstock
- selection of powerhouse equipment based on load of 500 kw

E) Interface with Environmental Consultant

F) Capital Cost Estimate and Construction Schedule

G) Power and Energy Costs (determined by Yukon Hydro Company Limited)

H) Report and Drawings

3. STUDY SCHEDULE

It is proposed that the conceptual engineering study commence in August. A draft letter report will be submitted in the middle of October for review and comment by YECL/APL. If the proposed development is economically feasible, the Feasibility Study can be undertaken in late October. The drilling and survey program should be undertaken as early as possible in the study. A streamflow metering program should be undertaken during the winter and following spring. A draft report will be submitted in June 1983.

5. ESTIMATE OF STUDY COST

Phase I - Conceptual Engineering Study

	Manhours
Data Collection	25
Hydrology Evaluation	140
Field Reconnaissance, Conceptual Design/Cost Estimate	220
Letter-type Report	100
TOTAL	485

Estimated Cost of Engineering Services	$ 22,800
Disbursements	
- Mapping Confirmation	$ 3,000
- Travel/Communications	$ 2,500
TOTAL COST	$ 28,300

Phase II - Feasibility Engineering Study

The estimate of study costs for the Feasibility Study is approximately $77,000. The scope of work and cost of engineering services will be reevaluated after completion of studies of Phase I.

We thank you for the opportunity to submit this letter proposal and look forward to a continuing working relationship. If you have any questions concerning the above please do not hesitate to contact us.

Yours very truly

G.A. Alexander
Vice President and
Regional Manager

c.c. Mr. R.H. Choate
Dr. J.R. Frey
Mr. J. Murray

DJR/pc

APPENDIX E

Economic Assumptions and Data

Economic Assumptions and Data

Economic Assumptions

1. Discount rate/Rate of return = 13.0%
2. Escalation rate = 6%
3. Real escalation rate on the diesel fuel price = 0% and 2%
4. Load growth = 0% and 2%
5. Income tax = full rebate assumed
6. Annual revenue requirements are present worthed to a reference year (1984)
7. Diesel fuel price = 34.69 cents/litre (1984 $)
8. Diesel plant heat rate = 3.302 kWh/litre (11 445 KJ/kWh) = kWh/gallon

Power Plant Assumptions

A. Hydro

1.	Lifetime (depreciation)	= 50 years straightline
2.	Capital cost	= 3.155 $ Million (1984 $) including transmission capital (0.7 $ Million) (Exclusive of AFUDC and land acquisition)
		= 3.35 $ Million installed cost (1984 $)
3.	Capacity	= 500 kW available 97% of the time in an average year
4.	Annual Energy	= 4.3 Gw.h in an average year
5.	Operating Cost	= Assumed to be the same as the status quo's, since the diesel backup is required all the time
6.		= The largest diesel unit (500 KW) would remain installed as backup. In the 2% load growth scenario an additional unit or one larger unit would be required after year 10.

7. Diesel Backup Energy = 29.4 MW.h of diesel energy (approximately 9 000 litres) is required annually under the zero growth assumption

B. Diesel

1. Current Installation (Teslin)

300 kW (Caterpillar)
500 kW (Caterpillar)
350 kW (Caterpillar)
1 150 kW Total

2. Lifetime (depreciation) = 500 kW new unit = 10 years straightline
= plant building = 30 years straightline (required in 1985)

3. Capital Cost = 500 kW new unit = $120 000 (1984 $)
= plant housing = $100 000 (1984 $)

4. Operating Cost = Assumed the same as hydro, thus it is omitted in both cases

5. Reliability = The largest unit contingency is considered, ie. with the largest unit (500 kW) out, the rest of the diesel power plant should be able to meet the peak demand.

6. Unit Replacement = Diesel unit (500 kW equivalent) is replaced every 10 years starting in the year 11
= A 500 kW new unit is required in the year 22 in the case of the 2% load growth only to meet increased load

APPENDIX F

Detailed Economic Analysis

Detailed Economic Analysis

APPENDIX F

Table and Figure	Assumptions
1	Fuel escalation same as inflation rate 2% annual load growth
2	Fuel escalation same as inflation rate % load growth
3	Fuel escalation 2% greater than inflation 2% annual load growth
4	Fuel escalation 2% greater than inflation 0% load growth
5	1 $ Million capital grant Fuel escalation same as inflation rate 2% annual load growth
6	0.5 $ Million capital grant Fuel escalation same as inflation rate 2% annual load growth
7	Cost per kWh compared to fuel if demand met supply and fuel escalation same as inflation rate

Escalation Rate 6.00 %
Lifetime 50 Years
Fuel Escalation Rate 6.00 %
Load Growth 2.00 %

	HYDRO							DIESEL									DIFFERENCE		
Year	Rate Base	Return	Depn	Diesel Backup Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	Diesel Cost Cents/lite	Rate Base Bldg	Rate Base Replc't	Rate Base New Unit	Return	Depn	Demand Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	Savings	Savings P.W.	Savings C.P.W.
1	3350000	435500	67000	25449	6918	3094	505594	34.69				0		1715600	519564	180237	180237	-325357	-287927	-287927
2	3283000	426790	67000	32356	9798	3603	497393	36.77	106000			13780	3533	1749912	529955	194872	212185	-285208	-223359	-511286
3	3216000	418080	67000	24828	10547	4111	489191	38.98	102467			13321	3533	1784910	540554	210696	227550	-261642	-181331	-692617
4	3149000	409370	67000	35524	10758	4445	480815	41.32	98933			12861	3533	1820608	551365	227804	244199	-236616	-145121	-837738
5	3082000	400660	67000	37874	11470	5023	472683	43.80	95400			12402	3533	1857021	562393	246302	262237	-210446	-114222	-951960
6	3015000	391950	67000	41260	12495	5801	464751	46.42	91867			11943	3533	1894161	573641	266301	281777	-182973	-87885	-1039845
7	2948000	383240	67000	43025	13030	6412	456652	49.21	88333			11483	3533	1932044	585113	287925	302942	-153710	-65336	-1105181
8	2881000	374530	67000	44817	13573	7080	448610	52.16	84800			11024	3533	1970685	596816	311305	325862	-122748	-46173	-1151354
9	2814000	365820	67000	50305	15235	8423	441243	55.29	81267			10565	3533	2010099	608752	336583	350681	-90563	-30147	-1181501
10	2747000	357110	67000	51312	15540	9107	433217	58.61	77733			10105	3533	2050301	620927	363913	377552	-55666	-16398	-1197900
11	2680000	348400	67000	54449	16490	10244	425644	62.12	74200	214900		37583	25023	2091307	633345	393463	418069	30425	7932	-1189968
12	2613000	339690	67000	56576	17134	11283	417973	65.85	70667	193410		34330	25023	2133133	646012	425412	450435	66792	15409	-1174559
13	2546000	330980	67000	60451	18307	12779	410759	69.80	67133	171920		31077	25023	2175796	658933	459955	484956	105297	21498	-1153061
14	2479000	322270	67000	64750	19609	14509	403779	73.99	63600	150430		27824	25023	2219312	672111	497304	522083	146372	26446	-1126615
15	2412000	313560	67000	70237	21271	16683	397243	78.43	60067	128940		24571	25023	2263698	685554	537685	562368	190836	30385	-1096230
16	2345000	304850	67000	78242	23695	19499	391349	83.14	56533	107450		21318	25023	2308972	699265	581345	627686	236137	33412	-1062817
17	2278000	296140	67000	85598	25923	22645	385785	88.12	53000	85960		18065	25023	2355151	713250	628550	671638	285653	35769	-1027049
18	2211000	287430	67000	92247	27937	26096	380526	93.41	49467	64470		14812	25023	2402254	727515	679588	719423	338897	37554	-989495
19	2144000	278720	67000	102117	30926	30622	376342	99.02	45933	42980		11559	25023	2450299	742065	734771	771353	395011	38734	-950758
20	2077000	270010	67000	109096	33039	34678	371688	104.96	42400	21490		8306	25023	2499305	756906	794434	827763	456076	39579	-911179
21	2010000	261300	67000	118384	35852	39887	368187	111.26	38867	384860		55084	42019	2549291	772045	856942	956046	587859	45147	-866032
22	1943000	252590	67000	126754	38387	45270	364860	117.93	35333	346374	408000	102662	82819	2600277	787486	928688	1114170	749310	50926	-815107
23	1876000	243880	67000	134226	40650	50815	361695	125.01	31800	307888	367200	91895	82819	2652283	803235	1004098	1178813	817118	49145	-765962
24	1809000	235170	67000	145709	44128	58972	360642	132.51	28267	269402	326400	81129	82819	2705328	819300	1085631	1249579	888937	47314	-718648
25	1742000	226460	67000	158079	47874	67242	360702	140.46	24733	230916	285600	70362	82819	2759435	835686	1173784	1326966	966263	45513	-673135
26	1675000	217750	67000	169565	51352	76456	361206	148.88	21200	192430	244800	59596	82819	2814624	852400	1269095	1411510	1050305	43780	-629355
27	1608000	209040	67000	182972	55382	87403	363443	157.82	17667	153944	204000	48829	82819	2870916	869448	1372146	1503794	1140351	42065	-587290
28	1541000	200330	67000	196903	59631	99756	367086	167.29	14133	115458	163200	38063	82819	2928334	886837	1483564	1604446	1237360	40392	-546897
29	1474000	191620	67000	211214	63966	113427	372047	177.32	10600	76972	122400	27296	82819	2986901	904573	1604029	1716145	1342099	38771	-508126
30	1407000	182910	67000	225812	68386	128542	378452	187.96	7067	38486	81600	16530	82819	3046639	922665	1734277	1833626	1455174	37202	-470925
31	1340000	174200	67000	242606	73473	146388	387588	199.24	3533	689220	40800	95362	113255	3107572	941118	1875100	2083717	1696129	38373	-432552
32	1273000	165490	67000	260485	78887	166606	399096	211.20	608800	620298	730570	254757	162272	3169723	959940	2027358	2444387	2045291	40949	-391602
33	1206000	156780	67000	278720	84410	188966	412746	223.87	580507	551376	657513	233661	162272	3233118	979139	2191979	2587913	2175167	38539	-353063
34	1139000	148070	67000	297321	90043	213671	428741	237.30	568215	482454	584456	212566	162272	3297780	998722	2369968	2744806	2316065	36315	-316748
35	1072000	139360	67000	318503	96458	242627	448987	251.54	547920	413532	511399	191471	162272	3363736	1018696	2562409	2916152	2467165	34234	-282515
36	1005000	130650	67000	340159	103016	274672	472322	266.63	527627	344610	438342	170375	162272	3431011	1039070	2770477	3103125	2630803	32305	-250210
37	938000	121940	67000	367753	111373	314771	503711	282.63	507333	-275488	365285	149280	162272	3499631	1059852	2995440	3306992	2803281	30462	-219748
38	871000	113230	67000	395914	119901	359207	539437	299.59	487040	206744	292228	128184	162272	3569623	1081049	3238670	3529126	2988689	28750	-190997
39	804000	104520	67000	424638	128600	408385	579905	317.56	466747	137844	219171	107089	162272	3641016	1102670	3501650	3771011	3191106	27157	-163840
40	737000	95810	67000	453937	137473	462756	625566	336.61	446453	68922	146114	85994	162272	3713836	1124723	3785983	4034249	3408684	25671	-138169
41	670000	87100	67000	483822	146524	522814	676914	356.81	426160	1234290	73057	225356	216779	3788113	1147218	4093405	4535541	3858626	25717	-112452
42	603000	78390	67000	514305	155755	589699	734489	378.22	405867	1110861	1308340	367259	274556	3863075	1170162	4425790	5067605	4333116	25557	-86895
43	536000	69680	67000	545397	165172	662195	798875	400.91	385573	987432	1177506	331564	274556	3941153	1193565	4785164	5391287	4592411	23970	-62925
44	469000	60970	67000	577111	174776	742743	870713	424.97	365280	864003	1046672	295874	274556	4019976	1217437	5173719	5744150	4873437	22510	-40415
45	402000	52260	67000	609459	184573	831438	950698	450.47	344987	740574	915838	260182	274556	4100375	1241785	5593825	6120563	5177865	21165	-19250
46	335000	43550	67000	642455	194565	929038	1039588	477.49	324693	617145	785004	224490	274556	4182383	1266621	6048044	6547090	5507502	19923	673
47	268000	34840	67000	676110	204758	1036369	1138209	506.14	304400	493716	654170	188797	274556	4266030	1291953	6539145	7002499	5864290	18773	19446
48	201000	26130	67000	710438	215154	1154328	1247458	536.51	284107	370287	523336	153105	274556	4351351	1317793	7070124	7497785	6250327	17707	37152
49	134000	17420	67000	747741	226451	1287824	1372254	568.70	263813	246858	392502	117413	274556	4438378	1344148	7644218	8031187	6663933	16707	53859
50	67000	8710	67000	791649	239748	1445265	1520975	602.83	243520	123429	261668	81720	274556	4527146	1371031	8264928	8621205	7100229	15753	69611
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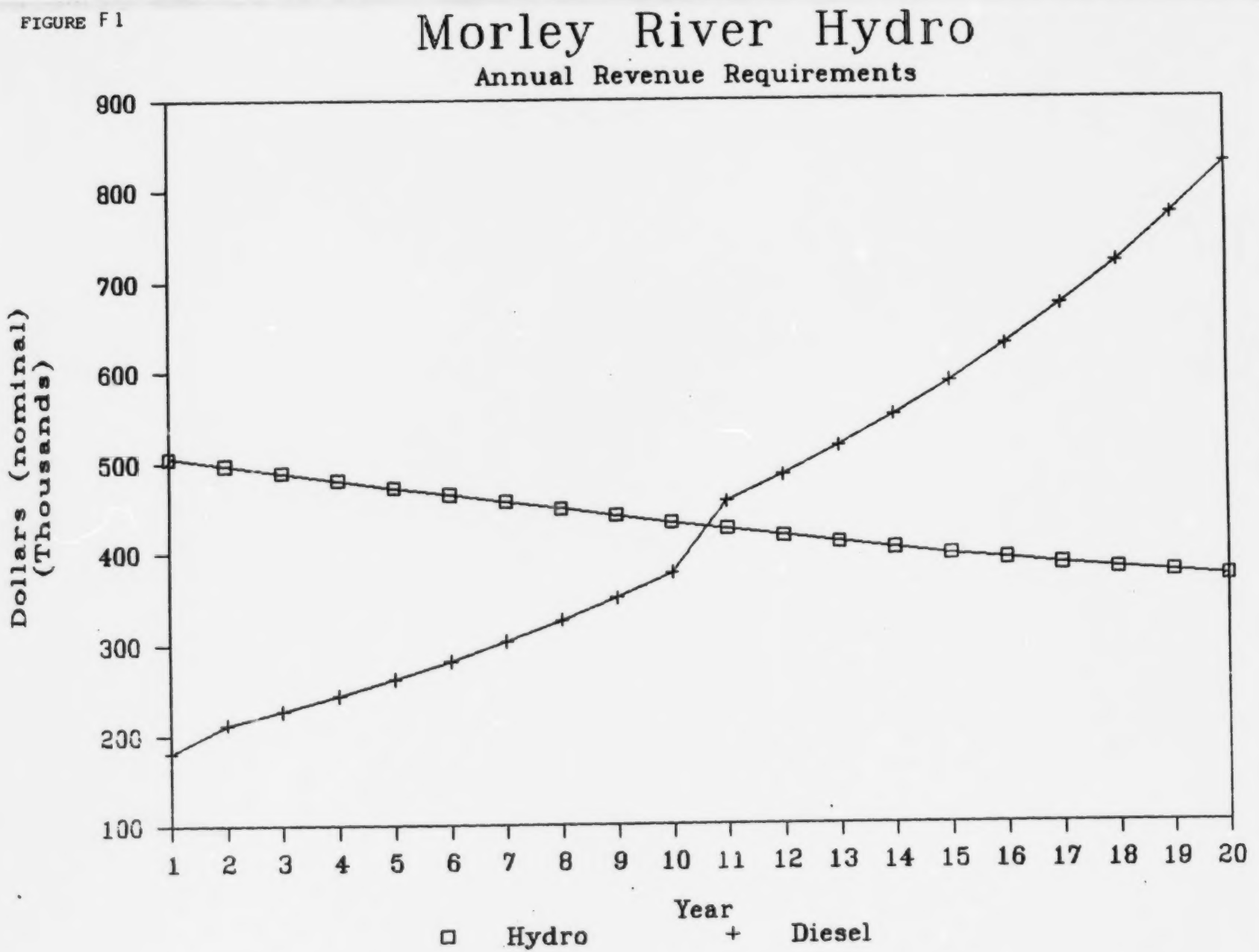
FIGURE F1


Morley River Hydro
Annual Revenue Requirements
Dollars (nominal)
(Thousands)
900
800
700
600
500
400
300
200
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Year
Hydro
Diesel

Retn/A/DISCOUNT Rate 13.00 %
Escalation Rate 6.00 %
Lifetime 50 Years
Fuel Escalation Rate 6.00 %
Load Growth 0.00 %

HYBRID

Year	Rate Base	Return	Depn	Diesel Backup Fu.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost
1	3350000	435500	67000	29449	8918	3094	505594
2	3283000	426790	67000	29449	8918	3279	497069
3	3216000	418080	67000	29449	8918	3476	488556
4	3149000	409370	67000	29449	8918	3685	480055
5	3082000	400660	67000	29449	8918	3906	471566
6	3015000	391950	67000	29449	8918	4140	463090
7	2948000	383240	67000	29449	8918	4389	454629
8	2881000	374530	67000	29449	8918	4652	446182
9	2814000	365820	67000	29449	8918	4931	437751
10	2747000	357110	67000	29449	8918	5227	429337
11	2680000	348400	67000	29449	8918	5541	420941
12	2613000	339690	67000	29449	8918	5873	412563
13	2546000	330980	67000	29449	8918	6225	404205
14	2479000	322270	67000	29449	8918	6599	395869
15	2412000	313560	67000	29449	8918	6995	387555
16	2345000	304850	67000	29449	8918	7414	379264
17	2278000	296140	67000	29449	8918	7859	370999
18	2211000	287430	67000	29449	8918	8331	362761
19	2144000	278720	67000	29449	8918	8831	354551
20	2077000	270010	67000	29449	8918	9361	346371
21	2010000	261300	67000	29449	8918	9922	338222
22	1943000	252590	67000	29449	8918	10518	330108
23	1876000	243880	67000	29449	8918	11149	322029
24	1809000	235170	67000	29449	8918	11818	313988
25	1742000	226460	67000	29449	8918	12527	305987
26	1675000	217750	67000	29449	8918	13278	298028
27	1608000	209040	67000	29449	8918	14075	290115
28	1541000	200330	67000	29449	8918	14919	282249
29	1474000	191620	67000	29449	8918	15815	274435
30	1407000	182910	67000	29449	8918	16763	266673
31	1340000	174200	67000	29449	8918	17769	258969
32	1273000	165490	67000	29449	8918	18835	251325
33	1206000	156780	67000	29449	8918	19966	243746
34	1139000	148070	67000	29449	8918	21163	236233
35	1072000	139360	67000	29449	8918	22433	228793
36	1005000	130650	67000	29449	8918	23779	221429
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38	871000	113230	67000	29449	8918	26718	206948
39	804000	104520	67000	29449	8918	28322	199842
40	737000	95810	67000	29449	8918	30021	192831
41	670000	87100	67000	29449	8918	31822	185922
42	603000	78390	67000	29449	8918	33731	179121
43	536000	69680	67000	29449	8918	35755	172435
44	469000	60970	67000	29449	8918	37901	165871
45	402000	52260	67000	29449	8918	40175	159435
46	335000	43550	67000	29449	8918	42585	153135
47	268000	34840	67000	29449	8918	45140	146980
48	201000	26130	67000	29449	8918	47849	140979
49	134000	17420	67000	29449	8918	50720	135140
50	67000	8710	67000	29449	8918	53763	129473
					total		445922

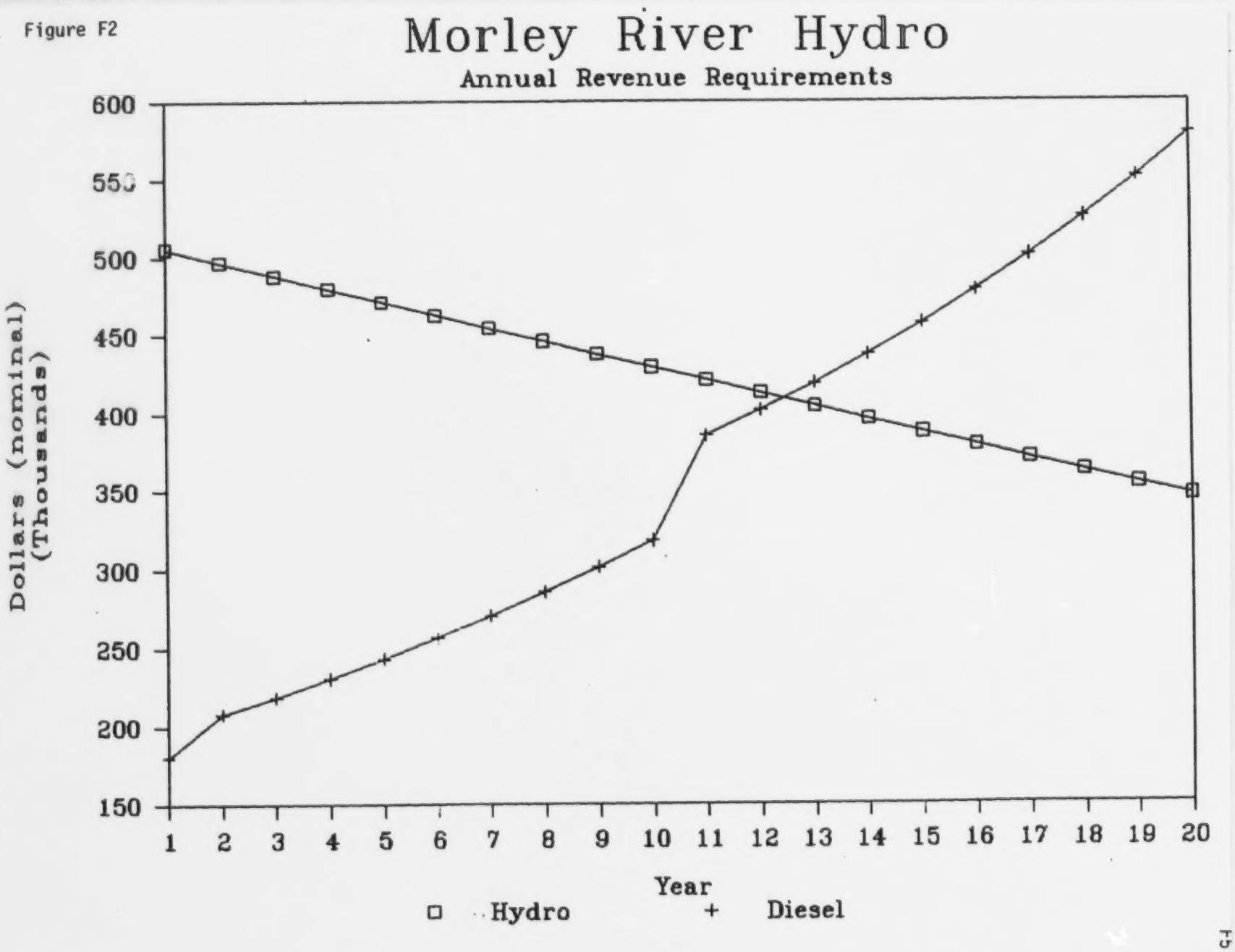
DIESEL

Diesel Cost Cents/lite	Rate Base Bldg	Rate Base Replc't	Rate Base New Unit	Return	Depn	Demand Fu.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost
34.69				0		1715600	519564	180237	180237
36.77	106000			13700	3533	1715600	519564	191051	208384
38.98	102447			13321	3533	1715600	519564	202514	219368
41.32	98933			12861	3533	1715600	519564	214665	231059
43.80	95400			12402	3533	1715600	519564	227565	243480
46.42	91867			11943	3533	1715600	519564	241197	256673
49.21	88333			11483	3533	1715600	519564	255669	270686
52.16	84800			11024	3533	1715600	519564	271009	285567
55.29	81267			10565	3533	1715600	519564	287270	301368
58.61	77733			10105	3533	1715600	519564	304506	318145
62.12	74200	214900		37583	25023	1715600	519564	322777	365383
65.85	70667	193410		34330	25023	1715600	519564	342143	401496
69.80	67133	171920		31077	25023	1715600	519564	362672	418772
73.99	63600	150430		27824	25023	1715600	519564	384432	437279
78.43	60067	128940		24571	25023	1715600	519564	407498	457092
83.14	56533	107450		21318	25023	1715600	519564	431948	478289
88.12	53000	85960		18065	25023	1715600	519564	457865	500953
93.41	49467	64470		14812	25023	1715600	519564	485337	525172
99.02	45933	42980		11559	25023	1715600	519564	514457	551039
104.96	42400	21490		8306	25023	1715600	519564	545324	578653
111.26	38867	384860		55084	42019	1715600	519564	578044	675147
117.93	35333	346374		49622	42019	1715600	519564	612726	704367
125.01	31800	307888		44159	42019	1715600	519564	649490	735669
132.51	28267	269402		38697	42019	1715600	519564	688459	769175
140.46	24733	230916		33234	42019	1715600	519564	729767	805020
148.88	21200	192430		27772	42019	1715600	519564	773553	843344
157.82	17667	153944		22309	42019	1715600	519564	819966	884295
167.29	14133	115458		16847	42019	1715600	519564	869164	928030
177.32	10600	76972		11384	42019	1715600	519564	921314	974717
187.96	7067	38486		5922	42019	1715600	519564	976592	1024534
199.24	3533	689220		90058	72455	1715600	519564	1035188	1197701
211.20	608800	620298		159783	89215	1715600	519564	1097299	1346297
223.87	588567	551376		148185	89215	1715600	519564	1163137	1400537
237.30	568213	482454		136587	89215	1715600	519564	1232925	1458728
251.54	547920	413532		124989	89215	1715600	519564	1306901	1521105
266.63	527627	344610		113391	89215	1715600	519564	1385315	1587921
282.63	507333	275688		101793	89215	1715600	519564	1468434	1659442
299.59	487040	206766		90195	89215	1715600	519564	1556540	1735950
317.56	466747	137844		78597	89215	1715600	519564	1649932	1817745
336.61	446453	68922		66999	89215	1715600	519564	1748928	1905142
356.81	426160	1234298		215859	143722	1715600	519564	1853864	2213445
378.22	405867	1110861		197175	143722	1715600	519564	1965096	2305993
400.91	385573	987432		178491	143722	1715600	519564	2083002	2405215
424.97	365280	864003		159807	143722	1715600	519564	2207982	2511511
450.47	344987	740574		141123	143722	1715600	519564	2340461	2625306
477.49	324693	617145		122439	143722	1715600	519564	2480888	2747050
506.14	304400	493716		103755	143722	1715600	519564	2629742	2877219
536.51	284107	370287		85071	143722	1715600	519564	2787526	3016320
568.70	263813	246858		66387	143722	1715600	519564	2954778	3164887
602.83	243520	123429		47703	143722	1715600	519564	3132964	3323490
							total	25978195	

DIFFERENCE

Savings	Savings P.W.	Savings C.P.W.
-325357	-287927	-287927
-288705	-226099	-514025
-269188	-186561	-700586
-248995	-152713	-853300
-228086	-123796	-977095
-206417	-99146	-1076241
-183943	-78187	-1154428
-160615	-60417	-1214845
-136383	-45400	-1260245
-111192	-32756	-1293001
-35550	-9270	-1302271
-11067	-2553	-1304824
14567	2974	-1301850
41410	7482	-1294368
69537	11118	-1283250
99024	14012	-1269238
129953	16272	-1252965
162411	17997	-1234968
196488	19268	-1215700
232283	20158	-1195542
336925	25875	-1169667
374260	25436	-1144231
413640	24878	-1119353
455188	24227	-1095125
499036	23505	-1071620
545316	22730	-1048889
594180	21918	-1026971
645781	21081	-1005890
700283	20230	-985660
757860	19375	-966285
938732	21238	-945048
1094972	21923	-923125
1156792	20496	-902629
1222496	19148	-883481
1292312	17932	-865529
1366492	16780	-848750
1445296	15706	-833044
1529002	14704	-818340
1617903	13769	-804572
1712312	12896	-791676
2027523	13513	-778163
2126871	12544	-765619
2232779	11654	-753965
2345648	10835	-743130
2465871	10080	-733051
2593915	9383	-723668
2730239	8740	-714927
2675341	8146	-706782
3029748	7596	-699186
3194017	7086	-692100

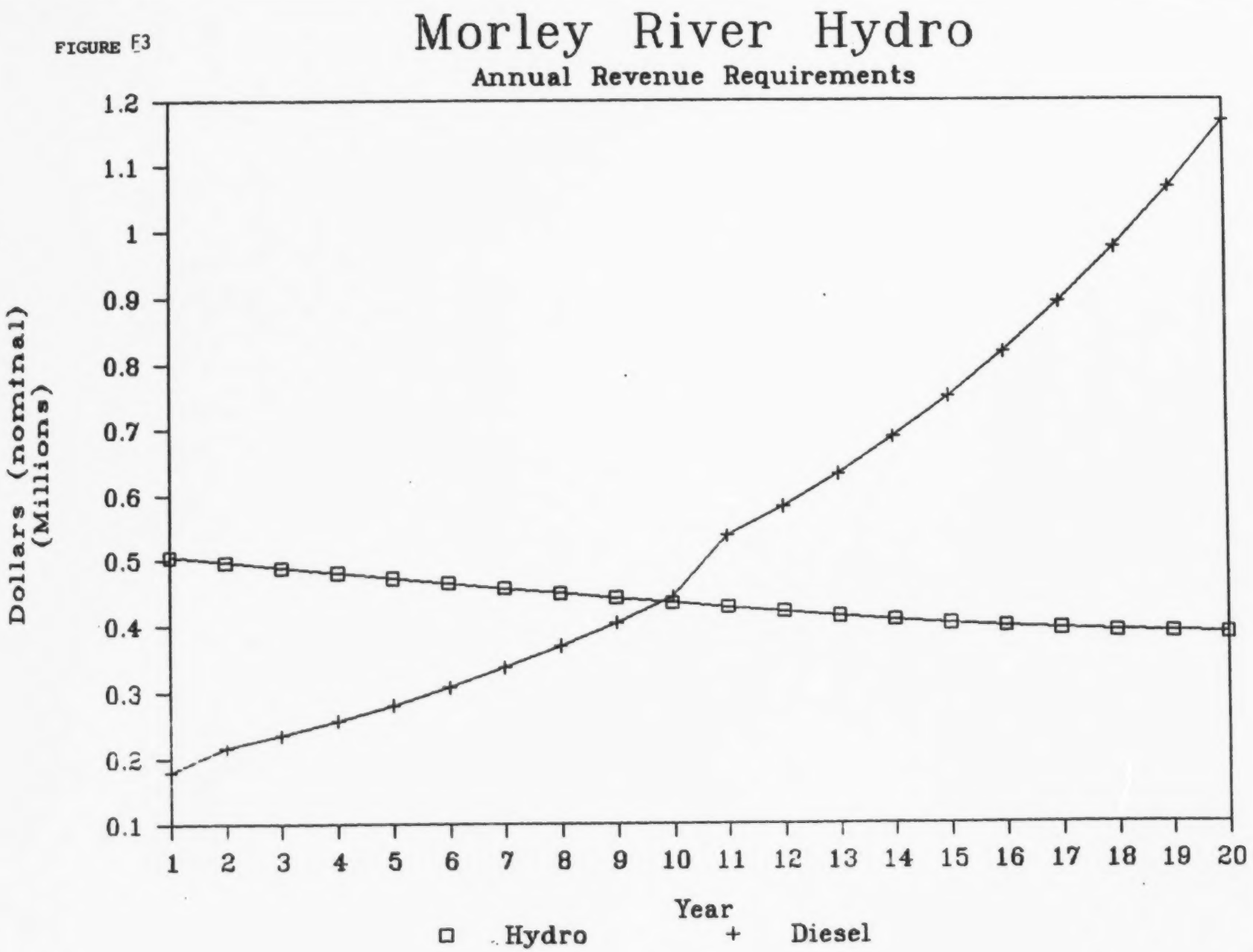
Figure F2


Morley River Hydro
Annual Revenue Requirements
Dollars (nominal)
(Thousands)
600
550
500
450
400
350
300
250
200
150
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Year
Hydro
Diesel

Lifetime 50 Years
Fuel Escalation Rate 8.00 %
Load Growth 2.00 %

Year	HYDRO Rate Base	Return	Depn	Diesel Backup Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	DIESEL Diesel Cost Cents/lite	Rate Base Bldg	Rate Base Replc't	Rate Base New Unit	Return	Depn	Demand Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	DIFFERENCE Savings	Savings P.W.	Savings C.P.W.
1	3350000	435500	67000	29449	8918	3094	505594	34.69				0		1715600	519564	180237	180237	-325357	-287927	-287927
2	3283000	426790	67000	32354	9798	3671	497461	37.47	106000			13780	3533	1749912	529955	198549	215862	-281599	-220533	-508460
3	3216000	418080	67000	34828	10547	4248	489348	40.46	102467			13321	3533	1784910	540554	218721	235575	-253772	-175877	-684337
4	3149000	409370	67000	35524	10758	4701	481071	43.70	98933			12861	3533	1820608	551345	240943	257338	-223733	-137220	-821557
5	3082000	400660	67000	37874	11470	5413	473073	47.20	95400			12402	3533	1857021	562393	265423	281359	-191715	-104055	-925612
6	3015000	391950	67000	41260	12495	6349	465319	50.97	91867			11943	3533	1894161	573641	292390	307866	-157453	-75627	-1001239
7	2948000	383240	67000	43025	13030	7173	457413	55.05	88333			11483	3533	1932044	585113	322097	337114	-120299	-31134	-1052374
8	2881000	374530	67000	44817	13573	8069	449599	59.45	84800			11024	3533	1970685	596816	354822	369380	-80220	-30175	-1082549
9	2814000	365820	67000	50305	15235	9782	442602	64.21	81267			10565	3533	2010099	608752	390872	404970	-37632	-12527	-1095076
10	2747000	357110	67000	51312	15540	10776	434886	69.35	77733			10105	3533	2050301	620927	430585	444223	9337	2751	-1092325
11	2680000	348400	67000	54449	16490	12350	427750	74.89	74200	214900		37583	25023	2091307	633345	474332	536938	109189	28465	-1063860
12	2613000	339690	67000	56576	17134	13859	420549	80.88	70667	193410		34330	25023	2133133	646012	522524	581878	161329	37220	-1026641
13	2546000	330980	67000	60451	18307	15992	413972	87.36	67133	171920		31077	25023	2175796	658933	575613	631713	217741	44455	-982186
14	2479000	322270	67000	64750	19609	18500	407770	94.34	63600	150430		27824	25023	2219312	672111	634095	686942	279172	50440	-931746
15	2412000	313560	67000	70237	21271	21673	402233	101.89	60067	128940		24571	25023	2263698	685554	698519	748113	345880	55303	-876443
16	2345000	304850	67000	78242	23695	26075	397925	110.04	56533	107450		21318	25023	2308972	699265	769489	815830	417905	59132	-817311
17	2278000	296140	67000	85598	25923	30809	393949	118.85	53000	85960		18065	25023	2355151	713250	847469	890757	496808	62209	-755102
18	2211000	287430	67000	92247	27937	35858	390288	128.35	49467	64470		14812	25023	2402254	727513	933792	973627	583339	64641	-690461
19	2144000	278720	67000	102117	30926	42870	388590	138.62	45933	42980		11559	25023	2450299	742065	1028865	1065247	676657	66356	-624105
20	2077000	270010	67000	109096	33039	49464	386474	149.71	42400	21490		8306	25023	2499305	756906	1133177	1165506	780032	67693	-556412
21	2010000	261300	67000	118384	35852	57969	386269	161.69	38867	384860		55084	42019	2549291	772045	1248308	1248412	959143	73661	-482751
22	1943000	252590	67000	126754	38387	67033	386623	174.62	35333	346374	408000	102662	82819	2600277	787486	1375136	1550618	1173995	79789	-402963
23	1876000	243880	67000	134226	40650	76663	387543	188.59	31800	307888	367200	91895	82819	2652283	803235	1514850	1669565	1302022	78369	-324653
24	1809000	235170	67000	145709	44128	89879	392049	203.68	28267	269402	326400	81129	82819	2705328	819300	1668759	1832707	1440658	76679	-247974
25	1742000	226460	67000	158079	47874	105310	398770	219.98	24733	230916	285600	70362	82819	2759435	835686	1838305	1991487	1592716	75020	-172954
26	1675000	217750	67000	169565	51352	121999	406749	237.57	21200	192430	244800	59596	82819	2814624	852400	2025077	2167492	1760743	73393	-99561
27	1608000	209040	67000	182872	55382	142099	418139	256.58	17667	153944	204000	48829	82819	2870916	869448	2230824	2382473	1944334	71722	-27839
28	1541000	200330	67000	196903	59631	165242	432572	277.11	14133	115458	163200	38063	82819	2928334	886837	2457476	2540358	2145784	70047	42209
29	1474000	191620	67000	211214	63966	191432	450052	299.27	10600	76972	122400	27296	82819	2986901	904573	2707156	2817271	2367219	68385	110594
30	1407000	182910	67000	225812	68386	221036	470946	323.22	7067	38486	81600	16530	82819	3046639	922665	2982203	3081552	2610606	66740	177334
31	1340000	174200	67000	242606	73473	256473	497673	349.07	3533	689220	40800	95362	113255	3107572	941118	3285194	3493812	2996139	67784	245119
32	1273600	165490	67000	260485	78887	297403	529893	377.00	608800	620290	730570	254757	162272	3169723	959940	3618970	4012999	3506106	70196	315315
33	1206900	156780	67000	278720	84410	343681	567461	407.16	588567	551376	657513	233661	162272	3233118	979139	3986658	4262591	3815130	67596	382911
34	1139000	148070	67000	297321	90043	395947	611017	439.73	568213	482454	584456	212566	162272	3297780	998722	4391702	4786540	4155524	65157	448068
35	1072000	139360	67000	318503	96458	458087	664447	474.91	547920	413532	511399	191471	162272	3363736	1018696	4837899	5191642	4527195	62818	510886
36	1005000	130650	67000	340159	103016	528373	726023	512.90	527627	344610	438342	170375	162272	3431011	1039070	5329430	5652077	4926054	60612	571497
37	938000	121940	67000	367753	111373	616933	805873	553.94	507333	275688	365285	149280	162272	3499631	1059852	5870900	6182452	5376578	58426	629923
38	871000	113230	67000	395914	119901	717310	897540	598.25	487040	206766	292228	128184	162272	3569623	1081049	6467383	6757840	5860300	56356	686279
39	804000	104520	67000	424638	128600	830901	1002421	646.11	466747	137844	219171	107089	162272	3641016	1102670	7124469	7393830	6391410	54392	740671
40	737000	95810	67000	453937	137473	959289	1122099	697.80	446453	68922	146114	85994	162272	3713836	1124723	7848315	8096581	6974482	52526	793197
41	670000	87100	67000	483822	146524	1104239	1258339	753.62	426160	1234290	73057	225356	216779	3788113	1147218	8645704	9087839	7829500	52182	845379
42	603000	78390	67000	514305	155755	1267715	1413105	813.91	405867	1110861	1308340	367259	274556	3863875	1170162	9524107	10165923	8752818	51624	897003
43	536000	69680	67000	545397	165172	1451903	1588583	879.03	385573	987432	1177506	331566	274556	3941153	1193565	10491757	11097880	9509297	49634	946636
44	469000	60970	67000	577111	174776	1659235	1787205	949.35	365280	864003	1046672	295874	274556	4019976	1217437	11557719	12128150	10340944	47765	994401
45	402660	52260	67000	609459	184573	1892418	2011678	1025.30	344987	740574	915838	260182	274556	4100375	1241785	12731984	13266722	11255043	46006	1040408
46	335000	43550	67000	642455	194565	2154461	2265011	1107.32	324693	617145	785004	224490	274556	4182383	1266621	14025553	14524599	12259588	44347	1084755
47	268600	34840	67000	676110	204758	2448709	2550549	1195.91	304400	493716	654170	188797	274556	4266030	1291953	15450549	15913903	13363354	42779	1127534
48	201600	26130	67000	710438	215154	2778881	2872011	1291.58	284107	370287	523336	152105	274556	4351251	1317793	17020325	17447986	14575975	41293	1168826
49	134000	17420	67000	747741	226451	3158773	3243193	1394.90	263813	246858	392502	117413	274556	4438378	1344148	18749590	19141559	15898364	39857	1208684
50	67000	8710	67000	791649	239748	3611804	3687514	1506.50	243520	123429	261668	81720	274556	4527146	1371031	26654548	21010825	17323311	38433	1247117
					total	3792414									total	43944408				

FIGURE E3


Morley River Hydro
Annual Revenue Requirements
Dollars (nominal)
(Millions)
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Year
Hydro
Diesel

Return/Discount Rate 15.00 %
Escalation Rate 6.00 %
Lifetime 50 Years
Fuel Escalation Rate 8.00 %
Load Growth 0.00 %

Table F4

		HYDRO										DIESEL						DIFFERENCE		
Year	Rate Base	Return	Depn	Diesel Backup Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	Diesel Cost Cents/lite	Rate Base Bldg	Rate Base Replc't	Rate Base New Unit	Return	Depn	Demand Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	Savings	Savings P.W.	Savings C.P.W.
1	3350000	435500	67000	29449	8918	3094	505594	34.69				0		1715600	519564	180237	180237	-325357	-287927	-287927
2	3283000	426790	67000	29449	8918	3341	497131	37.47	106000			13780	3533	1715600	519564	194656	211969	-285162	-223324	-511251
3	3216000	418080	67000	29449	8918	3609	488689	40.46	102467			13321	3533	1715600	519564	210228	227082	-261607	-181306	-692557
4	3149000	409370	67000	29449	8918	3897	480267	43.70	98933			12861	3533	1715600	519564	227046	243441	-236826	-145250	-837807
5	3082000	400660	67000	29449	8918	4209	471869	47.20	95400			12402	3533	1715600	519564	245210	261145	-210724	-114372	-952179
6	3015000	391950	67000	29449	8918	4546	463496	50.97	91867			11943	3533	1715600	519564	264827	280303	-183193	-87991	-1040170
7	2948000	383240	67000	29449	8918	4909	455149	55.05	88333			11483	3533	1715600	519564	286013	301030	-154120	-65510	-1105681
8	2881000	374530	67000	29449	8918	5302	446832	59.45	84800			11024	3533	1715600	519564	306894	323451	-123381	-46411	-1152092
9	2814000	365820	67000	29449	8918	5726	438546	64.21	81267			10565	3533	1715600	519564	333606	347704	-90843	-30240	-1182332
10	2747000	357110	67000	29449	8918	6185	430295	69.35	77733			10105	3533	1715600	519564	360294	373933	-56362	-16604	-1198935
11	2680000	348400	67000	29449	8918	6679	422079	74.89	74200	214900		37583	25023	1715600	519564	389118	451724	29645	7728	-1191207
12	2613000	339690	67000	29449	8918	7214	413904	80.88	70667	193410		34330	25023	1715600	519564	420247	479600	65697	15157	-1176050
13	2546000	330980	67000	29449	8918	7791	405771	87.36	67133	171920		31077	25023	1715600	519564	453867	509967	104196	21273	-1154777
14	2479000	322270	67000	29449	8918	8414	397684	94.34	63600	150430		27824	25023	1715600	519564	490176	543023	145339	26259	-1128518
15	2412000	313560	67000	29449	8918	9087	389647	101.89	60067	128940		24571	25023	1715600	519564	529390	578984	189337	30273	-1098245
16	2345000	304850	67000	29449	8918	9814	381664	110.04	56533	107450		21318	25023	1715600	519564	571741	618083	236418	33452	-1064792
17	2278000	296140	67000	29449	8918	10599	373739	118.85	53000	85960		18065	25023	1715600	519564	617481	660569	286830	35916	-1028876
18	2211000	287430	67000	29449	8918	11447	365877	128.35	49467	64470		14812	25023	1715600	519564	666879	706716	340837	37769	-991107
19	2144000	278720	67000	29449	8918	12363	358083	138.62	45933	42980		11559	25023	1715600	519564	720229	756812	398729	39101	-952006
20	2077000	270010	67000	29449	8918	13352	350362	149.71	42400	21490		8306	25023	1715600	519564	777848	811177	460815	39991	-912016
21	2010000	261300	67000	29449	8918	14420	342720	161.69	38867	384860		55084	42019	1715600	519564	840076	937179	594459	45454	-866362
22	1943000	252590	67000	29449	8918	15574	335164	174.62	35333	346374		49622	42019	1715600	519564	907282	998923	663759	45111	-821251
23	1876000	243880	67000	29449	8918	16820	327700	188.59	31800	307888		44159	42019	1715600	519564	979864	1066043	738343	44407	-776844
24	1809000	235170	67000	29449	8918	18165	320335	203.68	28267	269402		38697	42019	1715600	519564	1058253	1138970	818634	43572	-733272
25	1742000	226460	67000	29449	8918	19618	313078	219.98	24733	230916		33234	42019	1715600	519564	1142914	1218167	905089	42631	-690640
26	1675000	217750	67000	29449	8918	21188	305938	237.57	21200	192430		27772	42019	1715600	519564	1234347	1304138	998200	41608	-649032
27	1608000	209040	67000	29449	8918	22883	298923	256.58	17667	153944		22309	42019	1715600	519564	1333694	1397423	1098500	40521	-608511
28	1541000	200330	67000	29449	8918	24714	292044	277.11	14133	115458		16847	42019	1715600	519564	1439742	1498608	1206565	39387	-569124
29	1474000	191620	67000	29449	8918	26691	285311	299.27	10600	76972		11384	42019	1715600	519564	1554921	1608325	1323014	38220	-530904
30	1407000	182910	67000	29449	8918	28826	278736	323.22	7067	38486		5922	42019	1715600	519564	1679315	1727256	1448520	37031	-493872
31	1340000	174200	67000	29449	8918	31132	272332	349.07	3533	689220		90058	72455	1715600	519564	1813660	1976174	1703842	38548	-455325
32	1273000	165490	67000	29449	8918	33622	266112	377.00	608800	620298		159783	89215	1715600	519564	1958753	2207751	1941639	38874	-416451
33	1206000	156780	67000	29449	8918	36312	260092	407.16	588507	551376		148185	89215	1715600	519564	2115453	2352853	2092761	37079	-379371
34	1139000	148070	67000	29449	8918	39217	254287	439.73	568213	482454		136587	89215	1715600	519564	2284690	2510492	2256204	35376	-343995
35	1072000	139360	67000	29449	8918	42355	248715	474.91	547920	413532		124989	89215	1715600	519564	2467465	2681669	2432954	33759	-310236
36	1005000	130650	67000	29449	8918	45743	243393	512.90	527627	344610		113391	89215	1715600	519564	2664862	2867468	2624075	32222	-278014
37	938000	121940	67000	29449	8918	49402	238342	553.94	507333	275688		101793	89215	1715600	519564	2878051	3069059	2830717	30761	-247254
38	871000	113230	67000	29449	8918	53355	233585	598.25	487040	206766		90195	89215	1715600	519564	3108295	3287705	3054120	29370	-217884
39	804000	104520	67000	29449	8918	57623	229143	646.11	466747	137844		78597	89215	1715600	519564	3356959	3524771	3295628	28047	-189837
40	737000	95810	67000	29449	8918	62233	225043	697.80	446453	68922		66999	89215	1715600	519564	3625515	3781729	3556686	26786	-163051
41	670000	87100	67000	29449	8918	67212	221312	753.62	426160	1234299		215859	143722	1715600	519564	3915556	4275137	4053826	27018	-136033
42	603000	78390	67000	29449	8918	72588	217978	813.91	405867	1110861		197175	143722	1715600	519564	4228801	4569698	4351719	25666	-110367
43	536000	69680	67000	29449	8918	78396	215076	879.03	385573	987432		178491	143722	1715600	519564	4567105	4889318	4674243	24397	-85970
44	469000	60970	67000	29449	8918	84667	212637	949.35	365280	864003		159807	143722	1715600	519564	4932473	5236003	5023365	23203	-62767
45	402000	52260	67000	29449	8918	91441	210701	1025.30	344987	740574		141123	143722	1715600	519564	5327071	5611917	5401216	22078	-40689
46	335000	43550	67000	29449	8918	98756	209306	1107.32	324693	617145		122439	143722	1715600	519564	5753237	6019398	5810093	21017	-19672
47	268000	34840	67000	29449	8918	106656	208496	1195.91	304400	493716		103755	143722	1715600	519564	6213496	6460973	6252477	20015	344
48	201000	26130	67000	29449	8918	115189	208319	1291.58	284107	370287		85071	143722	1715600	519564	6710576	6939369	6731050	19069	19412
49	134000	17420	67000	29449	8918	124404	208824	1394.90	263813	246858		66387	143722	1715600	519564	7247422	7457531	7248707	18173	37585
50	67000	8710	67000	29449	8918	134356	210066	1506.50	243520	123429		47703	143722	1715600	519564	7827215	8018641	7808575	17324	54909
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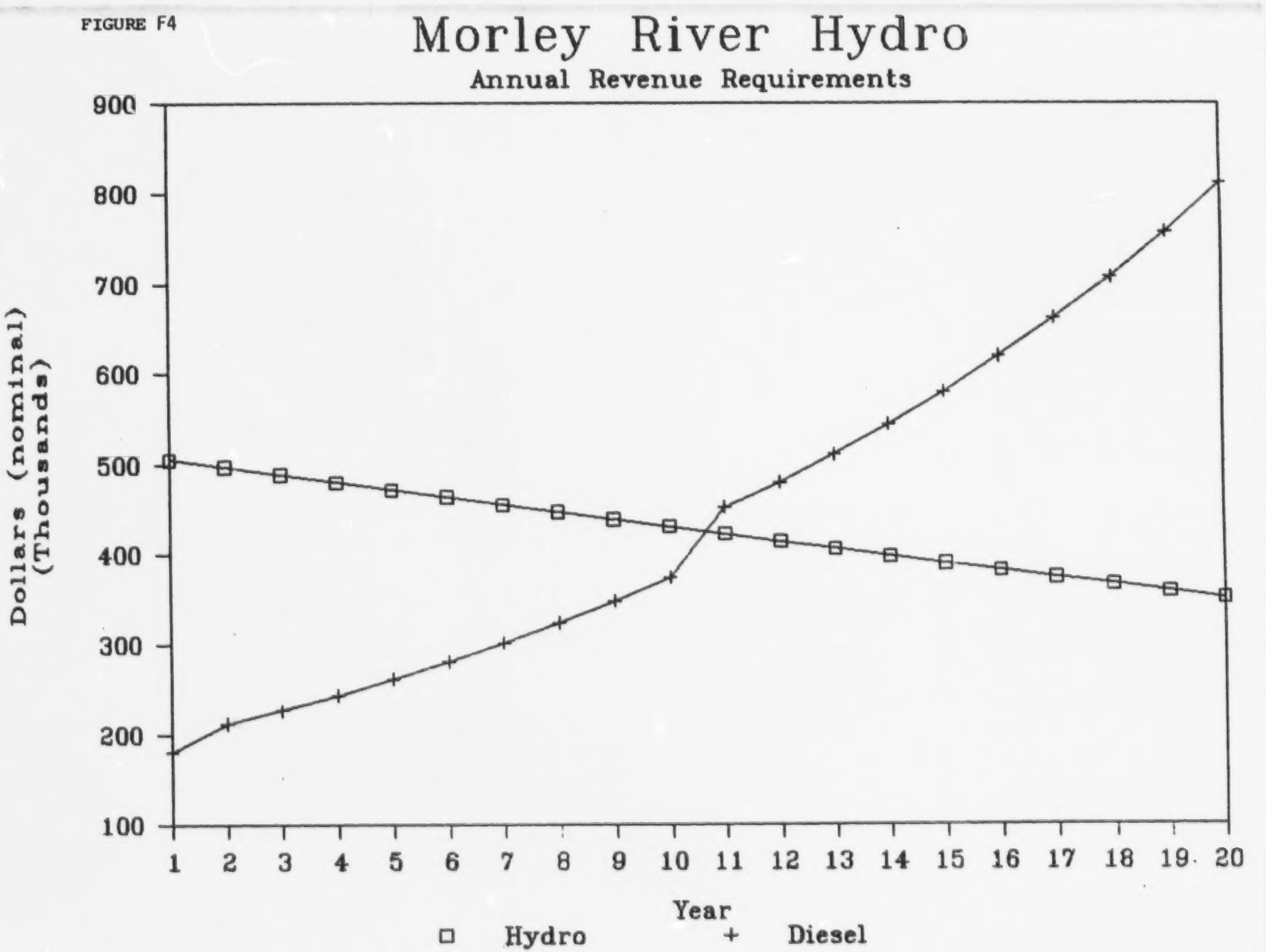
FIGURE F4


Morley River Hydro
Annual Revenue Requirements
900
800
700
600
500
400
300
200
100
Dollars (nominal)
(Thousands)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Year
Hydro
Diesel

Lifetime 50 Years
Fuel Escalation Rate 6.00 %
Load Growth 2.00 %

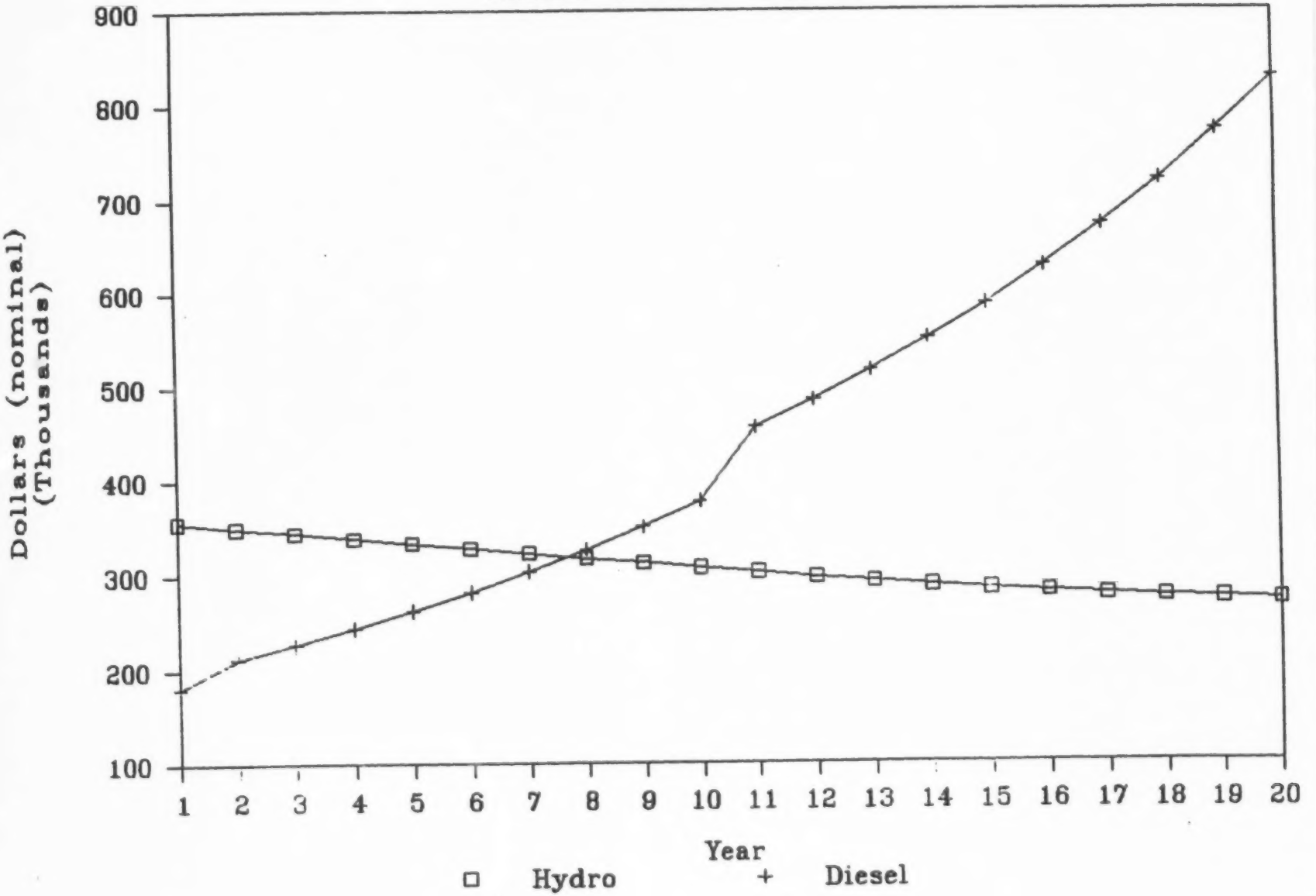
Year	HYDRO Rate Base	HYDRO Return	HYDRO Depn	HYDRO Diesel Backup Kw.h	HYDRO Fuel Req'd liter	HYDRO Fuel Cost Dollar	HYDRO Total Cost	DIESEL Diesel Cost Cents/lite	DIESEL Rate Base Bldg	DIESEL Rate Base Replc't	DIESEL Rate Base New Unit	DIESEL Return	DIESEL Depn	DIESEL Demand Kw.h	DIESEL Fuel Req'd liter	DIESEL Fuel Cost Dollar	DIESEL Total Cost	DIFFERENCE Savings	DIFFERENCE Savings P.W.	DIFFERENCE Savings C.P.W.
1	2350000	305500	47000	29449	8918	3094	355594	34.69				0		1715680	519584	180237	180237	-175357	-155183	-155183
2	2303000	299390	47000	32354	9798	3403	349993	36.77	106000			13780	3533	1749912	529955	194872	212185	-137808	-107924	-263107
3	2256000	293280	47000	34928	10547	4111	344391	38.98	102467			13321	3533	1784910	540554	210696	227550	-116842	-80977	-344084
4	2209000	287170	47000	35524	10758	4445	338615	41.32	98933			12861	3533	1820608	551365	227804	244199	-94416	-57907	-401991
5	2162000	281060	47000	37874	11470	5023	333083	43.80	95400			12402	3533	1857021	562393	246302	262237	-70846	-38453	-440444
6	2115000	274950	47000	41260	12495	5801	327751	46.42	91867			11943	3533	1894161	573641	266301	281777	-45973	-22082	-462526
7	2068000	268840	47000	43025	13030	6412	322252	49.21	88333			11483	3533	1932044	585113	287925	302942	-19310	-8208	-470734
8	2021000	262730	47000	44817	13573	7080	316810	52.16	84800			11024	3533	1970685	596816	311305	325862	9052	3405	-467329
9	1974000	256620	47000	50305	15235	8423	312043	55.29	81267			10565	3533	2010099	608752	336583	350681	38637	12862	-454467
10	1927000	250510	47000	51312	15540	9107	306617	58.61	77733			10105	3533	2050301	620927	363913	377552	70934	20896	-433570
11	1880000	244400	47000	54449	16490	10244	301644	62.12	74200	214900		37583	25023	2091307	633345	393463	456069	154425	40258	-393312
12	1833000	238290	47000	56576	17134	11283	296573	65.85	70667	193410		34330	25023	2133133	646012	425412	484765	188192	43417	-349895
13	1786000	232180	47000	60451	18307	12779	291959	69.80	67133	171929		31077	25023	2175796	658933	459955	516056	224097	45753	-304143
14	1739000	226070	47000	64750	19609	14509	287579	73.99	63600	150450		27824	25023	2219312	672111	497304	550151	262572	47441	-256702
15	1692000	219960	47000	70237	21271	16663	283643	78.43	60067	128970		24571	25023	2263698	685554	537685	587279	303636	48549	-208153
16	1645000	213850	47000	78242	23695	19699	280549	83.14	56533	107490		21318	25023	2308972	699265	581345	627686	347137	49119	-159035
17	1598000	207740	47000	85598	25923	22845	277585	88.12	53000	85960		18065	25023	2355151	713250	626550	671638	394053	49343	-109692
18	1551000	201630	47000	92247	27937	26096	274726	93.41	49467	64470		14812	25023	2402254	727515	675588	719423	444697	49278	-60414
19	1504000	195520	47000	102117	30926	30622	273142	99.02	45933	42980		11559	25023	2450299	742065	734771	771353	498211	48857	-11558
20	1457000	189410	47000	109096	33039	34678	271088	104.96	42400	21490		8306	25023	2499305	756906	794434	827763	556676	48310	36752
21	1410000	183300	47000	118384	35852	39887	270187	111.26	38867	384860		55084	42019	2549291	772045	856542	954046	685859	52673	89425
22	1363000	177190	47000	126754	38387	45270	269460	117.93	35333	346374	408000	102662	62819	2600277	787486	928688	1114170	844710	57409	146834
23	1316000	171080	47000	134226	40650	50815	268895	125.01	31800	307888	367200	91895	62819	2652283	803235	1004698	1178813	909918	54727	201560
24	1269000	164970	47000	145709	44128	58472	270442	132.51	28267	269402	326400	81129	62819	2705328	819300	1085631	1249579	979137	52115	253675
25	1222000	158860	47000	158079	47874	67242	273102	140.46	24733	230916	285600	70362	62819	2759435	835686	1173784	1326966	1053863	49639	303314
26	1175000	152750	47000	169565	51352	76456	276206	148.88	21200	192430	244800	59596	62819	2814624	852400	1269195	1411510	1135305	47323	350637
27	1128000	146640	47000	180872	55382	87403	281043	157.82	17667	153944	204000	48829	62819	2870916	869448	1372146	1503794	1222751	45105	395742
28	1081000	140530	47000	196903	59631	99756	287286	167.29	14133	115458	163200	38063	62819	2928334	886837	1483564	1604446	1317160	42997	438739
29	1034000	134420	47000	211214	63966	113427	294847	177.32	10600	76972	122400	27296	62819	2986901	904573	1604629	1714145	1419299	41001	479741
30	987000	128310	47000	225812	68386	128542	303852	187.96	7067	38486	81600	16530	62819	3046639	922665	1734277	1833626	1529774	39109	518849
31	940000	122200	47000	242606	73473	146368	315568	199.24	3533	689220	40800	95362	113255	3107572	941118	1875100	2083717	1768129	40002	558851
32	893000	116090	47000	260485	78887	166606	329696	211.20	608800	620298	730570	254757	162272	3169723	959940	2027358	2444387	2114691	42339	601190
33	846600	109980	47000	278720	84410	188966	345946	223.87	580507	551376	657513	233661	162272	3233118	979139	2191979	2587913	2241967	39723	640913
34	799000	103870	47000	297321	90043	213671	364541	237.30	568213	482454	584456	212586	162272	3297780	998722	2369968	2744806	2380265	37321	678234
35	752000	97760	47000	316503	96458	242627	387387	251.54	547920	413532	511399	191471	162272	3363736	1018696	2562409	2916152	2528765	35088	713323
36	705000	91650	47000	340159	103016	274672	413322	266.63	527627	344610	438342	170375	162272	3431011	1039070	2770477	3103125	2689803	33029	746352
37	658000	85540	47000	367753	111373	314771	447311	282.63	507333	275688	365285	149280	162272	3499631	1059852	2995440	3306992	2859681	31075	777427
38	611000	79430	47000	395914	119901	359207	485637	299.59	487040	206766	292228	128184	162272	3569623	1081049	3238670	3529126	3043489	29248	806695
39	564000	73320	47000	424638	128600	408385	528705	317.56	466747	137844	219171	107089	162272	3641016	1102670	3501650	3771011	3242306	27593	834288
40	517000	67210	47000	453937	137473	462756	576966	336.61	446453	68922	146114	85994	162272	3713836	1124723	3785983	4034249	3457284	26037	860325
41	470000	61100	47000	483822	146524	522814	630914	356.81	426160	1234290	73057	225356	216779	3788113	1147218	4092465	4535541	3904626	26023	886348
42	423000	54990	47000	514305	155755	589099	691089	378.22	405867	1110861	1368340	367259	274556	3863875	1170162	4425790	5067605	4376516	25813	912161
43	376000	48880	47000	545397	165172	662195	756075	400.91	385573	987432	1177506	331566	274556	3941153	1193565	4785164	5391287	4633211	24183	936344
44	329000	42770	47000	577111	174776	742743	832513	424.97	365280	864003	1046672	295874	274556	4019976	1217437	5173719	5744150	4911637	22687	959031
45	282000	36660	47000	609459	184573	831438	915098	450.47	344987	740574	915838	260182	274556	4100375	1241785	5593825	6128563	5213465	21311	980342
46	235000	30550	47000	642455	194565	929638	1006588	477.49	324693	617145	785004	224490	274556	4182383	1266621	6048944	6547090	5540502	20042	1000384
47	188000	24440	47000	676110	204758	1036369	1107809	506.14	304400	493716	654170	188797	274556	4266030	1291953	6539145	7062499	5894690	18870	1019254
48	141000	18330	47000	710428	215156	1154228	1219658	536.51	284107	370287	523336	153105	274556	4351351	1317793	7070124	7497785	6278127	17785	1037039
49	94000	12220	47000	745741	225851	1287824	1347054	568.70	263813	246858	392502	117413	274556	4438378	1344148	7644218	8034187	6689133	16770	1053809
50	47000	6110	47000	781649	239748	1445265	1498375	602.83	243520	123429	261668	81720	274556	4527146	1371031	8264928	8621205	7122829	15803	1069611
					total	3762414									total	43944404				

F10

FIGURE 5F5

Morley River Hydro

Annual Revenue Requirements



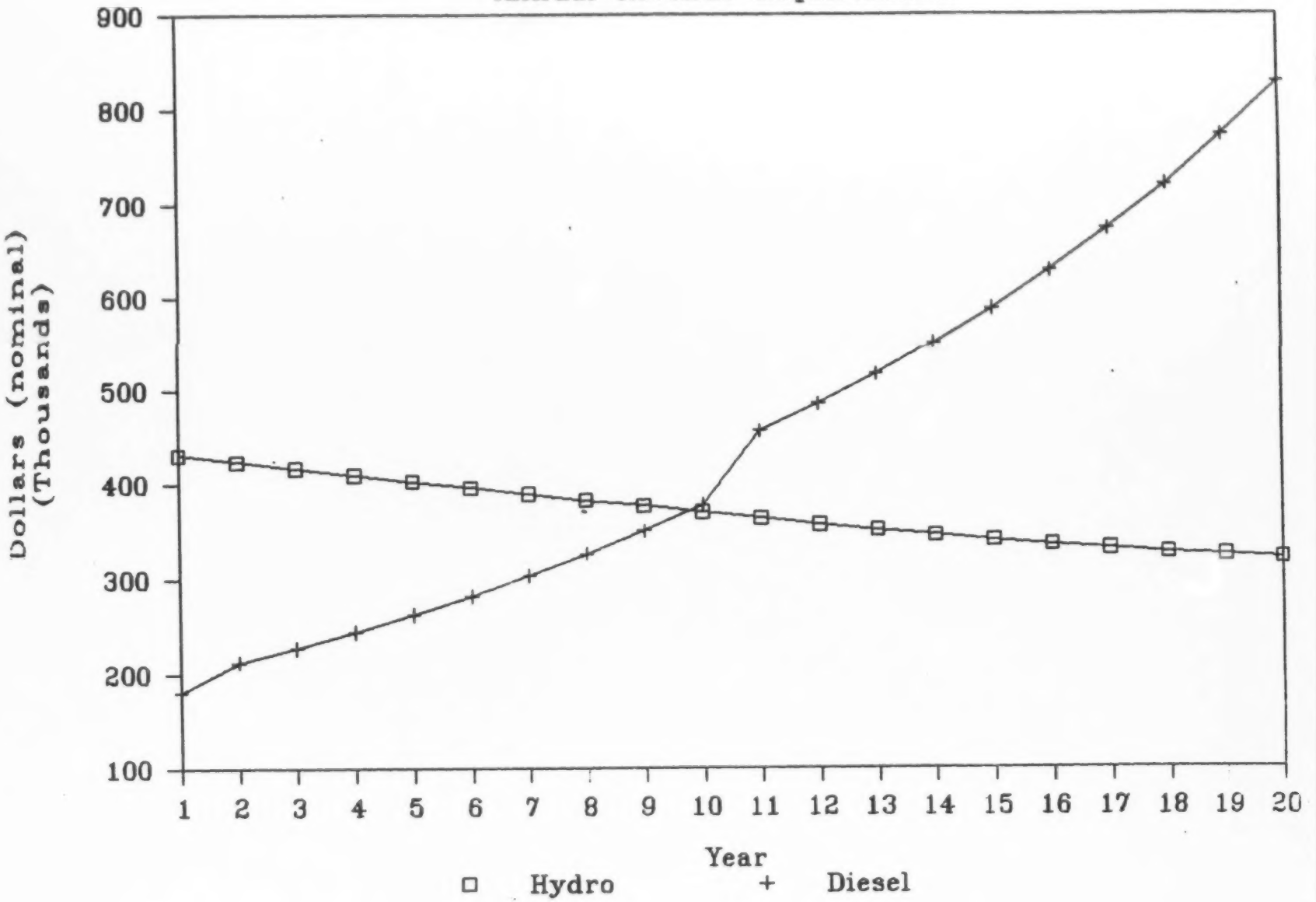
Escalation Rate 6.00 %
Lifetime 50 Years
Fuel Escalation Rate 6.00 %
Load Growth 2.00 %

		HYDRO						DIESEL									DIFFERENCE		
Year	Rate Base	Return	Depn	Diesel Backup Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	Diesel Cost Cents/lite	Rate Base Bldg	Rate Base Replc't	Rate Base New Unit	Return	Depn	Demand Kw.h	Fuel Req'd liter	Fuel Cost Dollar	Total Cost	Savings	Savings P.V.	Savings C.P.W.
1	2850000	370500	57000	29449	8918	3094	430594	34.69				0		1715600	519564	180237	180237	-250357	-221555	-221555
2	2793000	363090	57000	32354	9798	3603	423693	36.77	166000			13780	3533	1749912	529955	194872	212185	-211508	-165642	-387196
3	2736000	355680	57000	34828	10547	4111	416791	38.98	102467			13321	3533	1784910	540554	216696	227550	-189242	-131154	-518350
4	2679000	348270	57000	35524	10758	4445	409715	41.32	98933			12861	3533	1820608	551365	227804	244199	-165516	-101514	-619865
5	2622000	340860	57000	37874	11470	5023	402883	43.80	95400			12402	3533	1857021	562393	246302	262237	-140646	-76337	-696202
6	2565000	333450	57000	41260	12495	5801	396251	46.42	91867			11943	3533	1894161	573641	266301	281777	-114473	-54984	-751185
7	2508000	326040	57000	43025	13030	6412	389452	49.21	88333			11483	3533	1932044	585113	287925	302942	-86510	-36772	-787958
8	2451000	318630	57000	44817	13573	7080	382710	52.16	84800			11024	3533	1970685	596816	311305	325862	-56848	-21384	-809341
9	2394000	311220	57000	50305	15235	8423	376643	55.29	81267			10565	3533	2010099	608752	336583	350681	-25963	-8643	-817984
10	2337000	303810	57000	51312	15540	9107	369917	58.61	77733			10105	3533	2050301	620927	363913	377552	7634	2249	-815735
11	2280000	296400	57000	54449	16490	10244	363644	62.12	74200	214900		37583	25023	2091307	633345	393463	456069	92425	24095	-791640
12	2223000	288990	57000	56576	17134	11283	357273	65.85	70667	193410		34330	25023	2133133	646012	425412	484745	127492	29413	-762227
13	2166000	281580	57000	60451	18307	12779	351359	69.80	67133	171920		31077	25023	2175796	658933	459555	516056	164697	33625	-728602
14	2109000	274170	57000	64750	19609	14509	345679	73.99	63600	150430		27824	25023	2219312	672111	497364	550151	204472	36943	-691658
15	2052000	266760	57000	70237	21271	16683	340443	78.43	60067	128940		24571	25023	2263698	685554	537685	587279	246836	39467	-652192
16	1995000	259350	57000	78242	23695	19699	336049	83.14	56533	107450		21318	25023	2308972	699265	581345	627686	291637	41265	-610926
17	1938000	251940	57000	85598	25923	22845	331785	88.12	53000	85960		18065	25023	2355151	713250	628550	671638	339853	42556	-568370
18	1881000	244530	57000	92247	27937	26096	327626	93.41	49467	64470		14812	25023	2402254	727515	679588	719423	391797	43416	-524955
19	1824000	237120	57000	102117	30926	30622	324742	99.02	45933	42980		11559	25023	2450299	742065	734771	771353	446611	43796	-481158
20	1767000	229710	57000	109096	33039	34678	321388	104.96	42400	21490		8306	25023	2499305	756906	794434	827763	506376	43944	-437214
21	1710000	222300	57000	116384	35852	39887	319187	111.26	38867	384860		55084	42019	2549291	772045	856942	956046	636859	48910	-388304
22	1653000	214890	57000	126754	38387	45270	317160	117.93	35333	346374	408000	102662	82819	2600277	787486	928688	1114170	797010	54167	-334136
23	1596000	207480	57000	134226	40650	50815	315295	125.01	31800	307888	367200	91895	82819	2652283	803235	1004098	1178813	863518	51936	-282201
24	1539000	200070	57000	145709	44128	58472	315542	132.51	28267	269402	326400	81129	82819	2705328	819300	1085631	1249579	934037	49714	-232486
25	1482000	192660	57000	156079	47274	67242	316902	140.46	24733	230916	285600	70362	82819	2759435	835686	1173784	1326966	1010063	47576	-184910
26	1425000	185250	57000	169565	51352	76456	318706	148.88	21200	192430	244800	59596	82819	2814624	852400	1269695	1411510	1092805	45552	-139359
27	1368000	177840	57000	182072	55382	87403	322243	157.82	17667	153944	204000	48829	82819	2870916	869448	1372146	1563794	1181551	43585	-95774
28	1311000	170430	57000	196903	59631	99756	327186	167.29	14133	115458	163200	38063	82819	2928334	886837	1483564	1669446	1277260	41695	-54079
29	1254000	163020	57000	211214	63966	113427	333447	177.32	10600	76972	122400	27296	82819	2986901	904573	1604029	1741145	1380699	39886	-14193
30	1197000	155610	57000	225812	68386	128542	341152	187.96	7067	38486	81600	16530	82819	3046639	922665	1734277	1833626	1492474	38155	23962
31	1140000	148200	57000	242606	73473	146388	351588	199.24	3533	689220	40800	95362	113255	3107572	941118	1875160	2083717	1732129	39188	63150
32	1083000	140790	57000	260485	78887	166606	364396	211.20	608800	620298	730570	254757	162272	3169723	959940	2027358	2444387	2079991	41644	104794
33	1026000	133380	57000	278720	84410	188966	379346	223.87	588567	551376	657513	233661	162272	3233118	979139	2191979	2567913	2248165	41818	146612
34	969000	125970	57000	297321	90043	213671	396641	237.30	568213	482454	584456	212566	162272	3297780	998722	2369968	2744806	2497965	40661	215404
35	912000	118560	57000	316503	96458	242627	418187	251.54	547920	413532	511399	191471	162272	3363736	1018696	2562409	2916152	2660303	32667	248071
36	855000	111150	57000	340159	103016	274672	442822	266.63	527627	344610	438342	170375	162272	3431011	1039070	2770477	3103125	2831481	30769	278840
37	798000	103740	57000	367753	111373	314771	475511	282.63	507333	275688	365285	149280	162272	3499631	1059852	2595440	3304992	3016589	29009	307849
38	741000	96330	57000	395914	119901	359207	512537	299.59	487040	206766	292228	128184	162272	3569623	1081049	3238670	3529126	3216706	27375	335224
39	684000	88920	57000	424638	128600	408385	554305	317.56	466747	137844	219171	107089	162272	3641016	1102670	3501650	3771011	3432984	25854	361078
40	627000	81510	57000	453937	137473	462756	601266	336.61	446453	68922	146114	85994	162272	3713836	1124723	3785983	4034249	3881426	25870	386948
41	570000	74100	57000	483822	146524	522814	653914	356.81	426160	1234290	73057	225356	216779	3788113	1147218	4093405	4535541	4354816	25685	412633
42	513000	66690	57000	514305	155755	589099	712789	378.22	405867	1110861	1308340	367259	274556	3863875	1170162	4425790	5067605	4612811	24076	436709
43	456000	59280	57000	545397	165172	662195	778475	400.91	385573	987432	1177506	331566	274556	3941153	1193565	4785164	5391287	4892537	22599	459308
44	399000	51870	57000	577111	174776	742743	851613	424.97	365280	864003	1046672	295874	274556	4019976	1217437	5173719	5744150	5195465	21238	480546
45	342000	44460	57000	609459	184573	831438	932898	450.47	344987	740574	915838	260182	274556	4100375	1241585	5593825	6138563	5554002	19982	500528
46	285000	37050	57000	642455	194565	929638	1023088	477.49	324693	617145	785004	224490	274556	4182383	1266021	6048044	6547090	5879490	18821	519350
47	228000	29640	57000	676110	204758	1036369	1123609	506.14	304400	493716	654170	188797	274556	4266030	1291953	6529145	7002499	6264227	17746	537096
48	171000	22230	57000	710438	215154	1154228	1232558	536.51	284107	370287	523336	153105	274556	4351351	1317793	7070124	7497785	6676533	16738	553834
49	114000	14820	57000	745741	226451	1287634	1359454	568.70	263813	246858	392502	117413	274556	4438378	1344148	7644218	8036187	7111529	15778	569611
50	57000	7410	57000	791649	239748	1445265	1559675	602.83	243520	123429	261668	81720	274556	4527146	1371631	8264928	8621205			
			Total	3795414										Total	43944404					

FIGURE F6

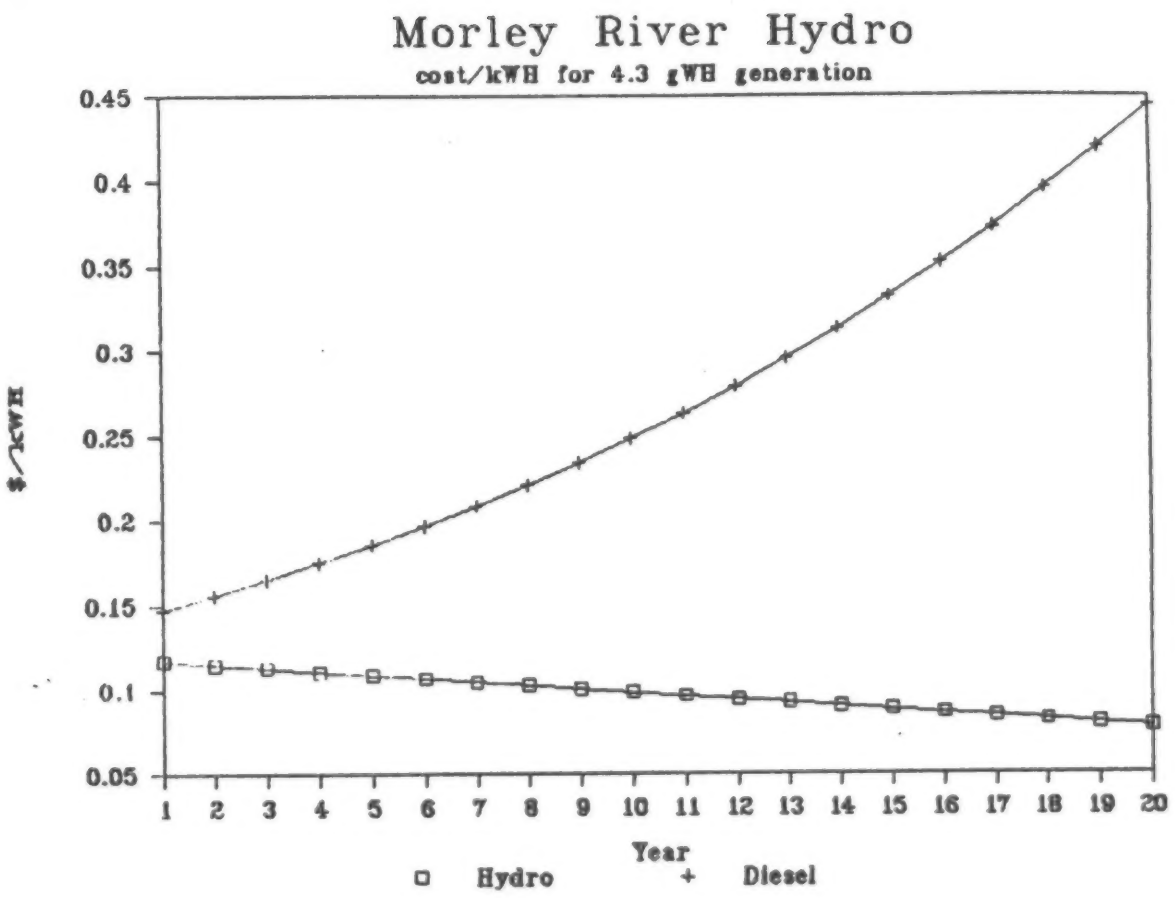
Morley River Hydro

Annual Revenue Requirements



F13

FIGURE F7


Morley River Hydro
cost/kWH for 4.3 gWH generation
$/kWH
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Year
Hydro
Diesel

APPENDIX G

Transmission Line Requirements

Transmission Line Requirements

The .25 Kv transmission line extending from the proposed Morley River hydro site to the community of Teslin was costed by Yukon Electrical Company Limited at $700 000 in direct capital costs (1984 dollars). The routing took the line from the proposed hydro site to the Alaska Highway and followed this to the community of Teslin, a total transmission distance of approximately 44 km.

There are no river crossings or other unusual structural requirements for the line. Brush clearing is indicated for virtually the entire length due to the inadequacy of existing brush clearances along the Alaska Highway. This contributed significantly to the $16 000 per km cost of the line.